This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

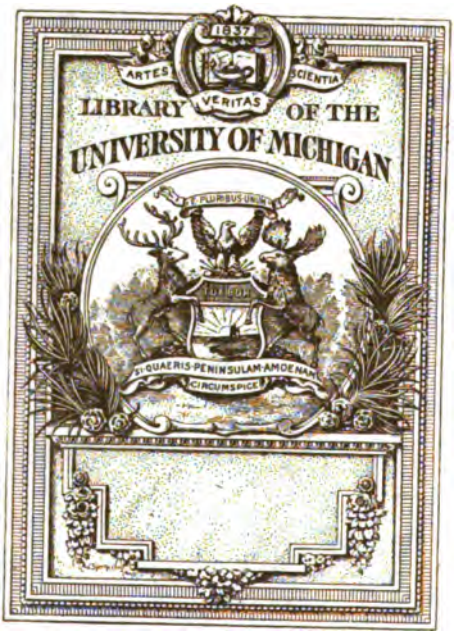
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

a39015 00003664 3b

Digitized by Google



Digitized by Google

SCIENCE LIBRARY
QL
47
.S353

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

TEXT-BOOK OF ZOOLOGY

Digitized by Google

Digitized by Google

TEXT-BOOK OF ZOOLOGY

TREATED FROM A BIOLOGICAL STANDPOINT

BY

DR. OTTO SCHMEIL

TRANSLATED FROM THE GERMAN BY RUDOLF ROSENSTOCK, M.A.

EDITED BY

J. T. CUNNINGHAM, M.A.

WITH NUMEROUS ILLUSTRATIONS

LONDON

ADAM AND CHARLES BLACK

1901

Digitized by Google

Digitized by Google

AUTHOR'S PREFACE

A FULL statement of the reasons which have prompted me to write this book, and of the principles on which the work is founded, has already been set forth in a separate publication,* which may therefore be accepted as a detailed preface to the present work. Briefly summarized, my views are that, in accordance with the present condition of the sciences of zoology and botany, as well as of the teaching art, certain changes in the methods of instruction have become necessary. Hitherto the task of the science teacher has been limited to a mere one-sided description and a dry classification of natural objects, whereas it has now become of primary importance to regard such objects in *all their various relations*, and to reveal to the pupil the intimate connection between the structure of living organisms and their vital functions; or, expressed in other words, *to replace the antiquated and purely descriptive form of instruction by a new method, based on physiologico-morphological, or, in short, biological, observations.* It is my opinion that only in this manner is it possible to convert instruction in natural history into a real mental discipline, second to none in *educational value*, and one, moreover, which, so far as the pupil's mental powers and the present state of our knowledge permit, is likely to supply him with a true insight into Nature and natural phenomena, and, finally, one which is capable of affording a powerful and lasting stimulus to that *sense for Nature* which is innate in the young.

The present work has been written from this standpoint for the purpose of supplying schools with the material necessary for instruction in zoology.

A superficial knowledge being quite valueless as an instrument of education or mental culture, I have, in the consideration of each animal group, selected a *single* example embodying the average type, which on the one hand exhibits as clearly as possible the organization of the group, and on the other hand will also serve as an illustration of its

* "Arguments for Reform in the Teaching of Natural History." Third edition. Stuttgart: Erwin Nägele, 1899.

234921

Digitized by Google

remaining members. Anyone who reads through a full and exhaustive examination of this kind, which endeavours to explain the *causal connection* between the structure and the functions of living organisms, will at once admit that instruction conveyed in this manner not only *presumes a much greater attention, a more careful observation, and more accurate inferences on the part of the scholar, but also a much deeper comprehension of Nature and natural phenomena* than ever was or can be obtainable by a mere description. Descriptions of the usual kind may be "read off" by any pupil, even the youngest, under the teacher's guidance, either from the natural object itself or a good illustration, and ought also to be furnished by the scholar himself as an incentive to independent activity on his part; but, in my opinion, these ought not to find a place in a school text-book.

That the method here recommended of studying natural objects does, however, by no means neglect the accurate observation of form and character is evident from the fact that, when these are not recognised, their significance also must remain unknown.

A thoroughly sound instruction conducted on these principles must, however, be based on direct observation; and I have therefore in this work, as far as was possible, selected types from our *native fauna*, and by preference *such as are of special importance to man and in the order of Nature as a whole*. This principle of selection has also been adopted in the case of the other more briefly considered species.

In my explanations, I have in places been obliged to make use of a somewhat *teleological manner of expression*, it being impossible to express relations of cause and effect pregnantly in any other form. Nor is it necessary to remind teachers that the general data (to be worked out by the teacher and pupil himself), viz., the definitions and characters of the separate groups, have been placed as headings to the several sections only in order to afford a convenient synopsis of the group and to avoid repetition.

I have endeavoured, even down to details, to shape my explanations in accordance with the present status of the natural sciences, while at the same time I have avoided reference to general theories not yet fully substantiated or unintelligible to the young. Being fully conscious that it is no longer within the powers of a single student to command the whole wide domain of zoology, I have invariably in doubtful and difficult cases called in the advice of distinguished specialists, which has always been bestowed with the utmost readiness and goodwill. I hereby, therefore, wish to express my warmest thanks to the gentlemen who have thus kindly assisted me, viz.: Dr. Ahlborn, Hamburg; Priv. Docent Dr. Brandes, Halle-on-Saale; Professor Dr. Dahl, Berlin; Dr.

Digitized by Google

Kluge, Magdeburg; Professor Dr. Kükenthal, Breslau; Dr. Sajo, Buda-Pesth; Professor Dr. Simroth, Leipzig; Dr. Smalian, Halle-on-Saale; Dr. Stingelin, Olten, and Dr. Tümpel, Gera. I further owe special thanks to Priv. Docent Dr. Hesse, Tübingen, for kindly undertaking the troublesome and time-absorbing task of reading the work in manuscript.

Through the excellent skill of the distinguished animal-painter, Herr Albert Kull, and the self-sacrificing generosity of the publisher, I have been enabled to adopt, in regard to the illustrations also, methods in part quite new in school text-books. I have represented the animals, not according to the usual hackneyed illustrations taken from stuffed or preserved museum specimens, but as living beings amidst their natural surroundings, and with special attention to the characteristic features of their mode of life.

In now presenting to the public this result of many years of labour and difficulty, I must not omit to state that I do not regard the work as by any means perfect or complete, but shall heartily welcome any suggestions or advice for its improvement.

Prompted as the work has been by a love of teaching and of Nature. I now send it forth into the world with the earnest wish that it may render teaching a labour of love to the teacher, and the study of Nature a delight to the young.

THE AUTHOR.

MAGDEBURG,
May 6, 1899.

Digitized by Google

Digitized by Google

EDITOR'S PREFACE

THIS English edition of Dr. Schmeil's text-book is translated from the second German edition, the issue of which, following close upon that of the first edition, proved that the book was very favourably received in Germany. I have little doubt that in England, also, the merits of the work will be appreciated. I have not undertaken to verify all the author's descriptions, nor have I made any alterations of a general character in the substance or the treatment. I have merely compared Mr. Rosenstock's excellent translation with the original text, and corrected the proofs, making here and there emendations in detail where a statement seemed to me open to doubt, or where differences between the fauna of Britain and Germany had to be indicated.

The book is far superior in many respects to any other elementary text-book of the subject known to me. It includes, so far as its aims and limits permit, the most recent advances which have been made, both in fact and principle. It provides sound scientific training by giving verifiable descriptions of empirical details, so that the pupil is taught to observe, to think, to compare, to generalize, not merely to remember statements. It treats animals always as living organisms, forming an excellent guide to that serious and accurate study of natural history, bionomics, or biology in a special sense, which is now recognised as one of the most important branches of zoology. Zoology, from this point of view, attracts children almost without exception, while for them the subject has little interest from any other point of view; the importance, therefore, of developing this natural interest into scientific study is evident.

The central idea of Dr. Schmeil's book is structural adaptation, and by the systematic review of the details of structure corresponding to varied physical conditions, the author produces a vivid impression of the

Digitized by Google

variety, the energy, and the complexity of animal life throughout the world. If in certain cases the idea is carried too far, as in reference to coloration, the author is only following some of the most eminent authorities on the subject; but, as a general rule, his interpretations have a sound foundation of physical science.

Zoology is the study of living animals and their relations to the matter and energy around them, and its special departments are of little educational or scientific value unless their bearing upon the main object of the science is understood and kept in view. This is the view which Dr. Schmeil takes of the science, and which he has exhibited in his book with remarkable skill and knowledge. The book will be of great assistance in the teaching of zoology as a part of that comprehension of the universe which constitutes scientific culture, and as a branch of scientific training for the development of the faculties of observation and reasoning. The more difficult and remote problems of the science are beyond the limits of the work, but as an introduction to more advanced study it seems to me excellent.

J. T. CUNNINGHAM.

April, 1900.

Digitized by Google

TABLE OF CONTENTS

FORMING A

SYNOPSIS OF THE PRINCIPAL DIVISIONS OF THE ANIMAL KINGDOM.

I. BODY CONSISTING OF NUMEROUS CELLS: MULTICELLULAR ANIMALS.

A. BILATERALLY SYMMETRICAL ANIMALS.

I. With an Internal Bony or Cartilaginous Skeleton.

PAGE

I. Phylum: Vertebrata 1

(*a*) Breathing by Lungs; covered with Hair; except Monotremes, bearing Living Young, which are nourished with Milk.

Class I.: Mammals 11
Order I.: Apes 17
„ II.: Lemurs 28
„ III.: Beasts of Prey 23
„ IV.: Seals 53
„ V.: Bats 59
„ VI.: Insect-Eaters 67
„ VII.: Rodents 75
„ VIII.: Proboscidians 89
„ IX.: Even-Toed Ungulates 92
„ X.: Odd-Toed Ungulates 119
„ XI.: Whales 125
„ XII.: Edentates 132
„ XIII.: Marsupials 134
„ XIV.: Monotremes 137

Digitized by Google

(*b*) Breathing by Lungs; covered with Feathers; Anterior Limbs in the Form of Wings; Oviparous.

	PAGE
Class II.: Birds	139
Order I.: Birds of Prey	158
„ II.: Woodpeckers	168
„ III.: Cuculine Birds	168
„ IV.: Parrots	171
„ V.: Swift-like Birds	178
„ VI.: Song-Birds	176
„ VII.: Pigeons	195
„ VIII.: Gallinaceous Birds	199
„ IX.: Cursorial Birds	205
„ X.: Waders	208
„ XI.: Ducks, Geese, and Swans	216
„ XII.: Pelican-like Birds	222
„ XIII.: Lariform Birds	228
„ XIV.: Divers	225

(*c*) Breathing by Lungs; covered with Horny or Bony Shields; mostly Oviparous.

Class III.: Reptiles	228
Order I.: Lizards	231
„ II.: Snakes	236
„ III.: Crocodiles	245
„ IV.: Tortoises	246

(*d*) Breathing by Gills when Young, in Adult Life by Lungs and Gills, or by Lungs alone; Skin smooth and soft; mostly Oviparous.

Class IV.: Amphibians	252
Order I.: Frogs and Toads	255
„ II.: Tailed Amphibians	261

(*e*) Breathing by Gills throughout Life; Skin usually bearing Scales; Limbs in the Form of Fins; mostly Oviparous.

Class V.: Fishes	266
Order I.: Bony Fishes	277
„ II.: Enamel-Scaled Fishes	297
„ III.: Sharks and Rays	299
„ IV.: Round-Mouthed Fishes	303
„ V.: Lancelets	304

Digitized by Google

II. With External Chitinous Skeleton and Jointed Limbs.

PAGE
II. Phylum: Arthropoda 307

(*a*) Breathing by Air-tubes; Body consisting of Three Distinct Portions — Head, Thorax, Abdomen; Three Pairs of Legs; generally Two Pairs of Wings.

Class I.: Insects 310
Order I.: Scale-Wings 318
„ II.: Sheath-Wings 339
„ III.: Hook-Wings 358
„ IV.: Two-Wings 375
„ V.: Net-Wings 382
„ VI.: Long-Beaks 385
„ VII.: Straight Wings 391
„ VIII.: False Net-Wings 399
„ IX.: No-Wings 408

(*b*) Breathing by Air-tubes; Body consisting of Only Two Portions —Head and Trunk; Every Segment of the Trunk furnished with One or Two Pairs of Legs; Wingless.

Class II.: Millipedes and Centipedes 404
Order I.: Centipedes 404
„ II.: Millipedes 405

(*c*) Breathing Air; Body usually consisting of Two Portions— Cephalo-thorax and Abdomen; Four Pairs of Legs; no Wings.

Class III.: Spider-like Animals 405
Order I.: True Spiders 405
„ II.: Harvest Spiders 411
„ III.: Scorpions 411
„ IV.: Book-Scorpions 411
„ V.: Mites 412

(*d*) Breathing by Gills (or only through the Skin); almost exclusively Aquatic.

Class IV.: Crustacea 412

Group I. Thoracostraca (provided with Carapace).
Order I.: Ten-Legged Crustacea 418
„ II.: Mantis-Shrimps 422

Group II. Arthrostraca (without Carapace).
„ III.: Sand and Shore Hoppers 428
„ IV.: Wood-Lice, etc. 428

Digitized by Google

GROUP III. ENTOMOSTRACA (LOWER CRUSTACEA).

PAGE
ORDER V.: OAR-LEGGED CRUSTACEA 424
„ VI.: BIVALVED CRUSTACEA 424
„ VII.: LEAF-LEGGED CRUSTACEA 425
„ VIII.: BARNACLES 425

III. BODY SOFT, WITHOUT JOINTED LIMBS; WITH A VENTRAL ORGAN OF LOCOMOTION (FOOT); A FOLD OF SKIN (MANTLE) ABOVE THE FOOT, WHICH PROTECTS THE RESPIRATORY ORGANS, AND USUALLY EXCRETES A CALCAREOUS SHELL.

III. Phylum: Mollusca 427

(*a*) ASYMMETRICAL MOLLUSCA WITH HEAD, FLAT-SOLED FOOT, AND USUALLY SPIRAL SHELL.

CLASS I.: GASTROPODS 428
ORDER I.: AIR-BREATHING GASTROPODS 428
„ II.: GILL-BREATHING GASTROPODS 434
„ III.: WINGED GASTROPODS 434

(*b*) SYMMETRICAL MOLLUSCS WITHOUT DISTINCT HEAD, WITH WEDGE-SHAPED FOOT, AND WITH BIVALVE SHELL.

CLASS II.: BIVALVES 435

(*c*) SYMMETRICAL MOLLUSCS WITH DISTINCT HEAD, WITH FOOT DEVELOPED INTO ARMS SURROUNDING THE MOUTH, AND POSTERIOR FUNNEL.

CLASS III.: CUTTLE-FISHES 442

IV. WITHOUT SEGMENTED LIMBS; BODY ENCLOSED BY A DERMO-MUSCULAR TUBE.

IV. Phylum: Vermes 446

(*a*) BODY CONSISTING OF NUMEROUS SIMILAR SEGMENTS.

CLASS I.: SEGMENTED WORMS 446
ORDER I.: BRISTLE-WORMS 446
„ II.: LEECHES 451

(*b*) BODY CYLINDRICAL, NOT SEGMENTED.

CLASS II.: THREAD-WORMS 452

(*c*) BODY FLAT.

CLASS III.: FLAT-WORMS 454
ORDER I.: TAPE-WORMS 454
„ II.: FLUKES 458

Digitized by Google

B. RADIALLY SYMMETRICAL ANIMALS.

V. Five-rayed Animals with Calcareous Deposits in the Skin, which frequently form Projecting Spines; with a Water-vascular System, and with Body Cavity, Intestine, and Bloodvessels.

PAGE
V. Phylum: Echinodermata 459

(*a*) Free, Star-shaped, or Five-cornered, the Arms usually passing gradually into the Disc-shaped Body.

Class I.: Star-Fishes 459

(*b*) Free, Star-shaped, Arms in Most Cases definitely articulated to the Disc-shaped Body.

Class II.: Brittle Stars 468

(*c*) Fixed by a Stalk either throughout Life or in the Young Stages.

Class III.: Feather Stars 468

(*d*) Without Arms, Spherical, Heart-shaped or Disc-shaped.

Class IV.: Sea-Urchins 464

(*e*) Cylindrical in Shape.

Class V.: Sea-Cucumbers 464

VI. Four or Six Rayed Animals with an Internal Cavity which represents Body Cavity, Intestine, and Bloodvessels.

VI. Phylum: Cœlenterata 465

(*a*) Form either that of Jelly-Fish (Medusa) or Polyp, without Gullet and without Partitions in the Body Cavity.

Class I.: Jelly-Fishes and Hydroids 469
Order I.: Lobed Jelly-Fishes 469
„ II.: Velate Jelly-Fishes and Hydroid Polyps 471

(*b*) With Gullet, and Partitions in the Body Cavity.

Class II.: Corals and Sea-Anemones 473

C. ASYMMETRICAL ANIMALS.

VII. Body asymmetrical, consisting of a Cellular Mass usually containing Spicules, and traversed by a System of Canals and Ciliated Chambers.

VII. Phylum: Porifera 476

Digitized by Google

II. BODY CONSISTING OF A SINGLE CELL.

PAGE

VIII. Phylum: Protozoa 479

(*a*) SHAPE CONSTANT; SURFACE ENTIRELY OR PARTIALLY CILIATED; WITH DEFINITE MOUTH AND ANUS.

CLASS I.: INFUSORIA 479

(*b*) SHAPE CONSTANT; WITH ONE OR A FEW LONG FLAGELLA IN PLACE OF CILIA.

CLASS II.: FLAGELLATA 482

(*c*) NAKED, OR FURNISHED WITH SHELLS OR SKELETONS; WITHOUT DEFINITE MOUTH OR ANAL OPENING.

CLASS III.: RHIZOPODA 488

THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS 485

NOTE.—It must not be supposed that the above synopsis includes the whole of the Animal Kingdom. There are many groups and peculiar forms which do not belong to any of the orders here named. Among them are the Sirenia, the Dipnoi, Balanoglossus and the Ascidians, the Rotifera, the Polyzoa, and Peripatus. These animals for the most part occupy less important positions in Nature, but in science their characters and relations are of the greatest importance. The study of these forms can most profitably be commenced when a sound knowledge of those considered in the present text-book has been acquired.

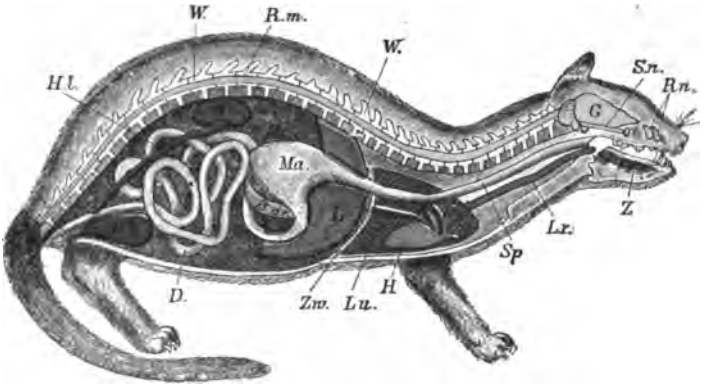
Digitized by Google

TEXT-BOOK OF ZOOLOGY

DIVISION OR TYPE: I. VERTEBRATES.

BILATERALLY symmetrical animals with an internal bony or cartilaginous skeleton. On the dorsal side of the vertebral column lies the central nervous system (brain and spinal cord); on the ventral side lie the organs of respiration, circulation and digestion. Usually four limbs, rarely two or none.

1. **Plan of Structure.**—All vertebrate animals are obliged to go in search of their food, and that for the most part over an extensive range. Consequently they must be endowed with the means of free locomotion. (Contrast them in this respect with plants and many animal parasites.)



LONGITUDINAL SECTION THROUGH THE BODY OF A VERTEBRATE (DIAGRAMMATIC).

W., Vertebral column; R.m., spinal marrow; G., brain; S.n., optic nerve; R.n., olfactory nerve, ramifying within the nasal cavities; Z., tongue; Sp., œsophagus; Ma., stomach; D., intestine; L., liver; B.dr., pancreas; Mi., spleen; Lr., trachea; Lu., lung; H., heart, with several bloodvessels; Zw., diaphragm; N., kidney; H.l., ureter; H.b., urinary bladder.

The smaller the resistance encountered by a creature in its progress through the air, the water, or on the earth, the more rapidly it can move, and the more easily is it able to obtain its food. Now, motion is most easily accomplished in the case of a body of rod-like, cylindrical shape,

Digitized by Google

especially if tapering to a point at its anterior end. Accordingly, the body of a vertebrate animal assumes, to a greater or less degree, the form of a pointed cylinder, and the movements of the animal are accordingly performed for the most part in the direction of its longitudinal axis.

The body of every vertebrate is divisible by one section into two similar halves, a left and a right portion. (Explain how such a section is made through the body of a man, bird or fish.) These halves bear a relation to each other similar to that of an object to its image reflected in a mirror. Hence, vertebrates are *laterally symmetrical* animals. Of those organs which are present in pairs (*e.g.*, eyes, limbs, etc.), one lies in each half of the body equidistant from the plane of section; the unpaired organs, on the other hand (*e.g.*, mouth, tail), lie in the plane of section. The internal organs also (*e.g.*, lungs, kidneys, œsophagus, trachea) for the most part assume similar positions.

On the other hand, those internal organs which occur singly—such as the liver, heart, intestine—and which do not lie in the plane of section, are always so placed as to throw an equal weight on both halves of the body. By this arrangement of organs, both body-halves maintain their balance, and an animal constructed on this type is accordingly capable of moving with greatest ease. (What do you observe in carrying a heavy load, such as a pail of water, on one side only?) People who have lost an arm frequently wear a wooden arm for the purpose of restoring their lost balance.

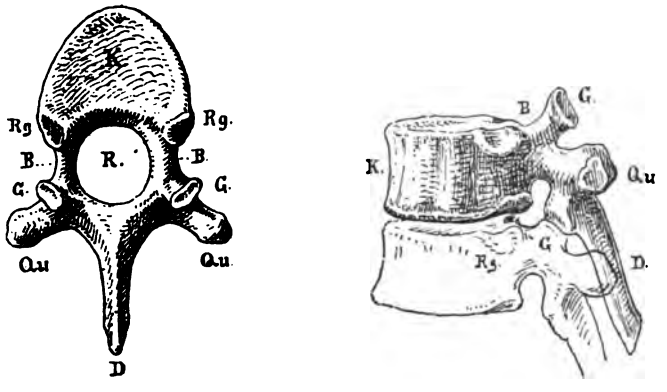
The body of every vertebrate consists of *head*, *trunk* and *limbs*. (State what organs are found on or in the head and in the trunk—chest and abdomen.) As a rule, the head and trunk are united by a neck, which represents, as it were, a movable stalk for the head. The number of limbs is at most two pairs; in some cases both pairs are absent (snakes), in others only one pair occurs (whales). The principal forms of limbs are fins, wings, legs. (Give examples.) What is the function of limbs?

2. **Skeleton.**—The body of every creature must possess a certain amount of solidity, though this, according to our notions, may often be extremely slight (*e.g.*, in infusoria, the threads or mycelium of fungi). Soft-bodied organisms like this, however, can only live in water, in the earth, or within other bodies, where their own bodies may be supported and protected on all sides. Deprived of this support, the creature shrivels up and perishes (*e.g.*, a jelly-fish, thrown up on the shore). Hence, animals living on land or in the air, as most vertebrates do, require a greater amount of solidity. This is attained by the possession of an *internal bony* (or cartilaginous) *framework, the skeleton* (see p. 9),

Digitized by Google

to which *are attached* the soft parts (*e.g.*, the muscles), and which *holds enclosed* in protective cavities (*e.g.*, cranium, thorax, eye-sockets, etc.) the more specially sensitive organs.

As animals must be capable of motion, it follows that the skeleton, instead of forming a single rigid mass, must consist of distinct movable parts, viz., the *bones*. Motion takes place in the *joints* (name the most important joints of the human body), and follows the mechanical laws of levers. (In the example of the motion of the lower arm illustrated on p. 4, indicate the fulcrum and the separate arms of the lever, also the points of application of the power and the weight.) The bones consist of two separate elements: an animal component, the *cartilage*, and a mineral component, or *bone ash*. (We can separate the cartilage by immersing fresh bones in dilute hydrochloric acid; the bone ash, which



HUMAN DORSAL VERTEBRÆ. IN THE LEFT-HAND FIGURE, SEEN FROM ABOVE; IN THE RIGHT-HAND FIGURE, SIDE-VIEW.

K., Centrum or body of vertebra; B., pedicle; R., foramen; D., spinous processes; Qu., transverse processes; G., articulating process uniting vertebra to the preceding vertebra; Rg., facets for articulation of the head of the rib to the vertebra.

consists for the most part of carbonate and phosphate of lime, may be obtained by subjecting bones to a red heat.) To the mineral constituents bone owes its stone-like rigidity, while the cartilaginous elements endow it with the pliancy and elasticity of steel.

A large bony rod traverses the whole length of the trunk. It forms the main support of the body, and consists of a number of almost similar bones, the *vertebræ*. These are placed in front of or above each other (as in man), like the stone slabs composing a pillar or column, whence this rod is appropriately named the *vertebral column* (vertebrata). It commences in the head and ends in the tail. The vertebræ are for the most part more or less movably united with each other. (Explain the significance of this in regard to motion.)

Digitized by Google

Two arches, which coalesce, forming a ring, extend dorsally (in some cases on the ventral side also) from the *body of the vertebra*, or *centrum*. The rings of all the vertebræ form a canal which encloses the *spinal marrow*. On the ventral side of the body are placed the organs of respiration, circulation and digestion. *This position of these organs relatively to the nervous system is peculiar to the vertebrata.* (Compare in this respect other animals, *e.g.*, the articulata.) A process, the (upper) *spinous process*, generally rises from the middle of the vertebral arch, and serves as a point of attachment for the muscles. Frequently lateral projections, the *transverse processes*, also occur. Long bones, the *ribs*, the number of which is variable, are connected with the vertebræ of the trunk. These act as a supporting framework for the walls of the cavities in which are lodged the internal organs (heart, lungs, intestines, etc.). Those ribs which are united with the *plate-like breast-bone*, or *sternum*, are termed *true ribs*; those which do not reach the sternum being called *false ribs*.

HUMAN ARM. A, FOREARM EXTENDED; B, FOREARM FLEXED.

O., Humerus, or upper arm; Sp., radius; E., ulna; Hw., carpus; M., metacarpal bones; 1, 2, 3, phalanges; Mu., biceps muscle (the part shaded deep black shows the extent of the muscle when the lower arm is flexed); S., tendons of the biceps; Sch., shoulder-blade (scapula); Schb., collar-bone (clavicle).

At its anterior termination the spinal canal widens out into a large cavity, the cranial chamber, which encloses the brain. The bones of this cranial case are called *cranial bones*. The other bones of the head, which form the face, are called *facial bones*. Both sets together form the *cranial skeleton*, or *skull*.

The limbs also are supported by solid skeletal elements. They are connected by special bones with the vertebral column—the fore-limbs by means of the *shoulder girdle*, the hind-limbs by means of the *pelvis*.

3. **Muscles.**—How are the bones put in motion? If the skin is removed from a vertebrate animal, it will be seen that the flesh which covers the bones does not form a continuous mass, but consists of numerous smaller or larger bands. These are the *muscles*. At their

Digitized by Google

tapering ends the muscles terminate in strong white cords, the *tendons*, which are attached to the bones. The action of the muscles may be easily demonstrated in the human arm. A large muscle (the biceps) lies on the inner side of the upper arm, and above is connected by two tendons with the shoulder, and below by a single tendon with the fore-arm. The contraction of this muscle is clearly observed if we place our other hand on it in such a manner that the thumb touches its upper end and the tips of the fingers come to lie on its lower end. As a result of this contraction, the forearm is drawn up after the manner of a drawbridge by its chain. Whilst, however, the bridge is raised by a force from without, in the present case the force lies within the muscle, viz., in its *capability of contracting*.

This capacity is the property of all muscles, and all movements are brought about by the contractions of the muscles. The motions of the heart also, of the intestines, etc., are effected by muscles. These movements, however, do not depend on the will of the animal, but are *involuntary*, whereas the motion of the forearm was of a *voluntary* nature.

4. **Nervous System.**—The biceps, as was said above, is contracted *at our will*. Now, the will is one of the mental activities which have their seat in the brain. (Brain and *spinal cord* form the main portion of the nervous system.) The brain transmits its orders to the muscles by special conductors, the *nerves*, which consist of fine white threads or fibres passing out from the brain and spinal cord, and dividing, like the branches of a tree, in finer and finer ramifications over the whole body. In the same manner as the electric telegraph carries our words to far-distant places, the nerves convey the orders of the brain to the muscles; and just as the telegraph calls forth in the distant place the motion by which our words are written down, so the nerves likewise call forth a motion, *i.e.*, the contraction of the muscles.

Take, for instance, the case of a cat which has caught sight of a mouse. The animal at once carries out a number of purposeful movements having for their object the capture, killing, and tearing to pieces of the mouse. Again, if we approach a limb to a hot object, we at once withdraw it, and so on. All these movements are replies to external stimuli. How do these stimuli affect the consciousness of man or animals? How are they transmitted to the brain? This, likewise, is effected by means of nerves, which, in contradistinction to the *nerves of motion* just referred to, are termed *nerves of sense*. The nerves of motion (motor nerves) accordingly conduct from within outwards (centrifugal nerves), while the nerves of sense (sensory nerves) conduct from without inwards (centripetal nerves.)

Thus, light acts as a stimulus only on the eye, sound waves only affect the ear, odoriferous substances the nose, flavours the tongue, warmth

Digitized by Google

and pressure the skin. From these organs the stimuli are conveyed by nerves to the brain, where they are manifested in our consciousness. Thus, the eye, the ear, the tongue, and the skin are the instruments of the senses (of sight, hearing, etc.), or, in other words, *implements or organs of sense*. In the vertebrata these organs exhibit a highly-perfected development.

5. **Respiration.**—No animal can continue to exist if its respiration is for any length of time interrupted—*i.e.*, if it is prevented from taking in fresh air. Nor is the kind of air so taken up to be left out of consideration, for any animal will speedily die of suffocation in an air not containing oxygen gas. If we examine the air which has been breathed out (*e.g.*, by man), we shall find that a portion of the oxygen has disappeared (prove this by showing that a flame burning in a vessel containing such air is extinguished much sooner than when burning in a vessel filled with atmospheric air), and this portion of oxygen has been replaced by carbonic acid gas. (Prove by breathing into lime-water.) Hence, *respiration consists in the consumption of oxygen and in the production of carbonic acid gas, and is accordingly a kind of combustion.* The exchange of the two gases is effected either by means of lungs or gills, according as the animal derives its oxygen direct from the atmosphere or from atmospheric air dissolved in water.

Let us explain this process of respiration more fully in a mammalian animal breathing by means of lungs. The air is taken in through the *nose* (or mouth), and conducted through the *trachea* to the *lungs*. (The upper part of the trachea is formed by the *larynx*, which is protected against the entrance of food by means of a lid or cover. Two bands —vocal chords—are stretched across the larynx, and are made to vibrate by means of currents of air of sufficient strength issuing from the lungs. Tones are thus produced in exactly the same manner as in a reed-pipe.) The tracheal tubes ramify in the lungs like the branches of a tree, and terminate in a very large number of very minute air-cells, the *pulmonary vesicles*. Each of these extremely fine air-cells is surrounded by a network of bloodvessels of hair-like fineness (*capillaries*), which contain blood very rich in carbonic acid. Two kinds of air, oxygen and carbonic acid gas, are thus separated by the fine wall of these air-bladders. Now, from an easily performed experiment, we learn that if two chambers which are separated by an animal membrane are filled with different gases, an exchange of the latter takes place through the membrane until the two gases become completely mingled. *In the same manner a mutual exchange between the oxygen and carbonic acid gas takes place in the pulmonary air-cells. The carbonic acid gas is expired, while the oxygen is taken up and carried off by the blood.*

Digitized by Google

6. **Circulation of the Blood** (see p. 15).—The capillaries of the lungs unite into larger and larger tubes, the *pulmonary veins*, which convey the bright-red blood to the heart. (In the fishes only, which see, is the blood conducted directly from the gills to the body.) The heart is a hollow muscle, divided into separate compartments, which drives the blood in rhythmic beats or pulsations, after the manner of a pump (the beat of the heart), through the *arteries* all over the body. The rhythmic beats of the heart are rendered manifest in these vessels, as the pulse. The large arteries divide up into finer and finer branches, and finally, as in the lungs, terminate in *capillaries*, which penetrate and enmesh all the parts of the body.

Through the walls of the capillaries an exchange of gases is effected in a reverse direction to that in the lungs. *The oxygen penetrates into the parts of the body (muscles, bones, nerves, etc.), whilst carbonic acid gas passes from these parts into the blood.*

The oxygen gas so taken up now unites chemically with the solid particles of the muscles, nerves, etc., and inasmuch as every chemical union of a body with oxygen is termed combustion, the muscles, nerves, etc., may be said to be slowly, but steadily, burning away. Just as carbonic acid gas is always produced in the combustion of carbonaceous bodies (*e.g.*, a candle), this poisonous gas, which has to be removed from the body, is also formed in the combustion (*i.e.*, respiration) of animals. Since, moreover, every combustion is attended by the production of heat (this need not always assume the form of flame, as may be seen in the process of putrefaction—*e.g.*, in manure-heaps), so also combustion in animals is accompanied by the development of heat, which we term *body heat*. (The more energetically we move about, as in bodily labour, running, etc., the deeper is our breathing, the more oxygen is conveyed to the blood, and the more heat is generated in our body.)

The blood, which has now become richer in carbonic acid gas, and has at the same time assumed a dark-red colour, collects in bloodvessels of larger and larger size, the *veins*, which conduct it to the heart.

From the heart it is pumped into the lungs, where, as already explained, it is freed from carbonic acid gas. In this manner the blood constantly pursues its way through the body, the whole process constituting what is termed the *circulation of the blood*.

The blood of vertebrata consists of a colourless fluid, in which are suspended an innumerable multitude of very small, disc-like red bodies (corpuscles), which impart to it its red colour.

In order to put a steam-engine into action, it is necessary to light a fire beneath the boiler, which gradually consumes the coal or wood. In exactly the same manner, as we have seen, particle after particle is con-

Digitized by Google

sumed in the combustion of the animal body. And just as our engine comes to a standstill if the supply of fresh fuel ceases, in the same manner the machine of the animal body would finally come to a stop if fresh fuel were not supplied to it. *This supply of fuel is likewise effected by the blood, which contains the materials of construction and combustion in a soluble form.*

These materials penetrate through the walls of the capillaries into the muscles, nerves, etc., replacing therein what has been consumed. If more material is introduced than has been used up, the body grows. But how does the blood obtain possession of these materials?

This is effected by the process of feeding and

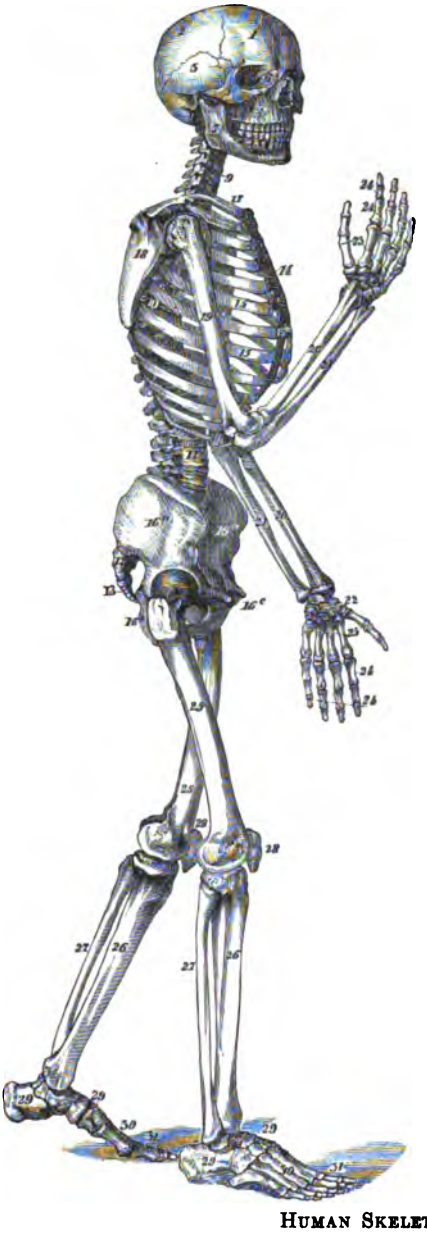
7. **Digestion.**—The food is seized, and frequently also divided up, by means of the *jaws* (in the vertebrata the jaws always move upward and downward; compare insects), and passes by the *mouth* into the *gullet*, or *œsophagus*, and thence to the *stomach*. Thence it is conveyed into the intestine, which as a rule consists of a narrower portion (*small intestine*) and of a wider portion (*large intestine*), which terminates at the anus.

It is the task of the digestion to convert the food into such a form as to be capable of entering the blood, and of being carried by it over the whole body. In herbivorous mammals and in man this transformation commences in the mouth, where the starch present in the food is converted into sugar by the action of the saliva, which is formed in the *salivary glands*. The saliva, moreover, has, in addition, the important function of moistening or lubricating the food, so as to render it fitter for deglutition (compare, on the other hand, fishes). In the stomach, by the action of the gastric juice, which is discharged from numerous glands in the stomach walls, the food is not only converted into a pulpy or pap-like mass, but its albuminous constituents also are dissolved.

From the stomach this mass passes into the small intestine. Here a fluid, the *bile*, is added to it, which is manufactured by the liver and frequently stored in a special sac, the *gall-bladder*. It is the function of the bile to divide the fats which are taken up with the food into infinitesimally fine droplets, which are able to penetrate the walls of the intestine. The *pancreatic juice*, which is furnished by the *pancreas*, has a similar function, but has the further action of converting starch into sugar, sugar in solution being likewise able to penetrate through animal membranes.

By the action of all these fluids the food is converted into a condition which renders it capable of being absorbed by the walls of the intestine. In addition to numerous capillaries, narrow tubes, the *lymphatic* vessels, which absorb the fluid nutriment and convey it to the blood, lie within

Digitized by Google



1. Frontal bone.
2. Parietal bone.
3. Temporal bone.
4. Upper jaw (maxilla).
5. Cheek-bone (malar bone).
6. Lachrymal bone.
7. Lower jaw (mandible).
8. Nasal bone.
9. Cervical vertebræ.
10. Thoracic vertebræ.
11. Lumbar vertebræ.
12. Sacral bone.
13. Coccygeal bone.
14. Sternum.
15. Ribs.
16, *a-c.* Pelvis.
17. Clavicle.
18. Scapula.
19. Humerus.
20. Radius.
21. Ulna.
22. Carpal bones.
23. Metacarpal bones.
24. Phalanges.
25. Femur.
26. Tibia.
27. Fibula.
28. Patella.
29. Tarsal bones.
30. Metatarsal bones.
31. Phalanges.

HUMAN SKELETON.

the walls of the intestine, the surface of the intestinal walls being frequently much folded for the purpose of increasing the absorbent surface and provided with peculiar prominences, or *villi*. Those materials of the

Digitized by Google

food which fail to be absorbed, and are consequently useless as nourishment, are separated in the form of *excrement*, or fæces.

8. **Organs of Secretion (or Excretion).**—As in the combustion of wood ash is left, so also in the combustion of animal bodies materials remain behind which are not only valueless, but actually noxious. These accordingly must be removed from the body. We have already become acquainted with one of these products, carbonic acid gas, and its separation by means of the lungs. There are, however, others which also require removal. Here again the blood plays the rôle of an intermediary agent. It takes up these waste products of assimilation in the capillaries, conveying them to the kidneys, and in most mammals to the skin. In both these organs they are separated in the form of urine and sweat respectively. (For the importance of sweat in another relation see under "Dog.")

9. The **Skin** of vertebrates consists (with one single exception, the Lancelet) always of two layers, the epidermis and the derma.

Digitized by Google

CLASS I.: MAMMALS (MAMMALIA).

WARM-BLOODED animals, as a rule covered with hair, breathing through lungs, and producing living young (with the exception of cloacal animals), which for a time at least they nourish with milk. The limbs, as a rule, are in the form of legs.

1. **Body Covering.**—The body is, as a rule, provided with a coating of hair. The air spaces enclosed between the hairs prevent excessive diffusion of the body-heat into the external medium, air being a bad conductor of heat. Animals, being very sensitive to an excessive loss of heat, are in need of such a covering. Experiments have shown that rabbits did not recover after their bodies had been cooled down to 18° C. (about 42° F.) and brought into a chamber of the same temperature. Hibernating animals, however—*e.g.*, the bat—can endure a much greater degree of cold.

2. **Skeleton** (compare pp. 2, 9).—The most important bones may be seen in the accompanying illustration, to which may be added the following remarks in regard to particular parts of the skeleton :*

(*a*) *Skull.*—The bones of the skull are not, for the most part, completely united, but are placed edge to edge, with projections of one bone fitting into notches of the other ; in this way *sutures* are formed. The upper jaws (maxillary bones), however, are firmly united with the bones of the skull, while the lower jaw (mandible) is connected with the skull (temporal bones) by means of an articulation.

(*b*) *Vertebral Column and Thorax.*—The vertebral column may be subdivided into the following regions: Cervical, dorsal, lumbar, sacral, and coccygeal. Only the dorsal vertebræ carry ribs.

(*c*) *The Shoulder Girdle, or Scapular Arch*, consists of the *shoulder-blade* (*scapula*), which in animals with specially active fore-limbs (*e.g.*, bats) is further supported by a *collar-bone*, or *clavicle*.

(*d*) *Pelvis.*—The bones of this skeletal part unite with each other on the ventral side, forming a closed girdle.

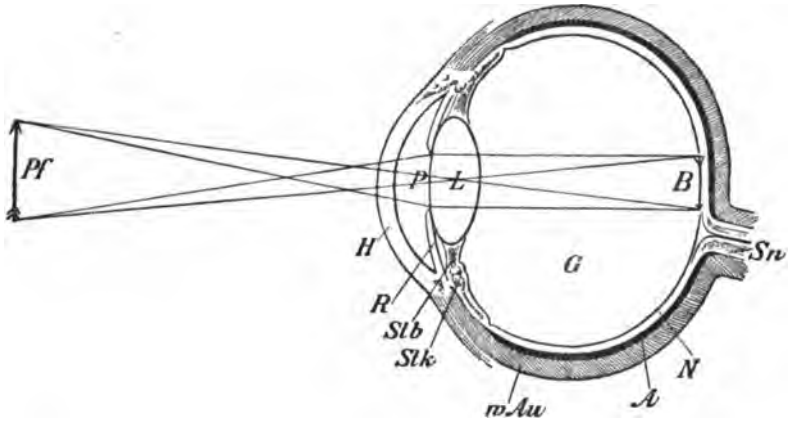
* The statements which follow are limited to an explanation of the special features mentioned in the description of mammals, and of the deviations of structure exhibited by other classes of the vertebrata.

Digitized by Google

(*e*) *Limbs.*—These portions of the skeleton display the most variable types of structure, according to the manner of locomotion of the animal under consideration. They are, however, always composed of the following parts:

The *fore-limb* consists of the upper arm, or humerus; the forearm, made up of two bones, the radius and ulna, of which the latter is often rudimentary; and the hand, or manus, consisting of the carpus, metacarpus and digits (fingers).

The *hind-limb* consists of the thigh-bone, or femur; the leg proper (crus), made up of two bones, tibia and fibula (the latter often rudimentary); and the foot, or pes, consisting of the tarsus, metatarsus, and digits (toes). The knee-joint is protected in front by a special bone, the kneecap, or patella.



VERTICAL SECTION THROUGH THE HUMAN EYE.

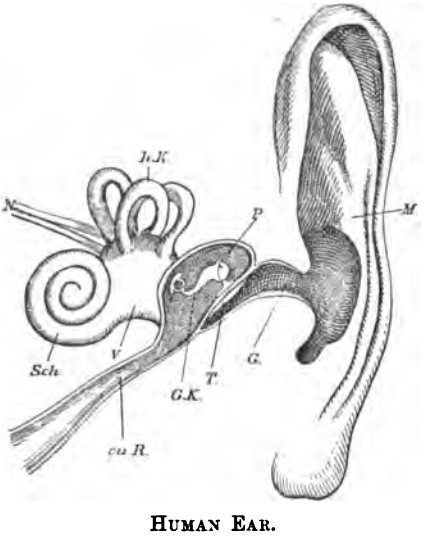
wAu., Sclerotic; H., cornea; A., choroid; R., iris; P., pupil; Sn., optic nerve; N., retina; L., lens; Stk. and Stb., ciliary muscle and ciliary fold, organs for maintaining the lens in a tense condition and for regulating the degree of its convexity; G., vitreous body; B., the image, on the retina, of the object Pf.

3. **Organs of Sense.**—(*a*) The *eyes* lie within protective cavities, the *orbits*. The wall of the *eyeball* is formed of three membranes. The outermost of these, the *sclerotic*, serves as a protecting covering. In front this covering is transparent like the purest glass, in order to permit the entrance of light into the interior of the eye. This transparent portion is termed the *cornea*. The second membranous layer is termed the *choroid*, and is well supplied with bloodvessels (supplying nutriment to the eye). From the circumference of the cornea the choroid stretches across the eye like a curtain, which is known as the *iris*. In the centre of the iris there is an aperture for the entrance of light, forming the *pupil*. This aperture contracts in a bright light, and dilates in a faint

Digitized by Google

light. The *optic nerve* enters at the posterior end of the eyeball. It penetrates the two outer membranes (sclerotic and choroid), and then expands in the form of the *retina* upon the inner side of the choroid. Directly behind the iris is a lens-shaped body, the *crystalline lens*. The space in front of the iris is filled with a watery fluid, the *aqueous humour*; that behind the lens with a gelatinous substance, the *vitreous body*. Both the aqueous humour and vitreous body as well as the lens are highly transparent.

The eye is constructed on the same plan as the camera of the photographer. On the retina, as on the sensitive plate of the camera, there is formed an inverted and diminished image of the external world, and the retina, being composed of nerve terminations sensitive to light, transmits the image to the brain. (What is the importance of eyelids, eyelashes and eyebrows?)



HUMAN EAR.

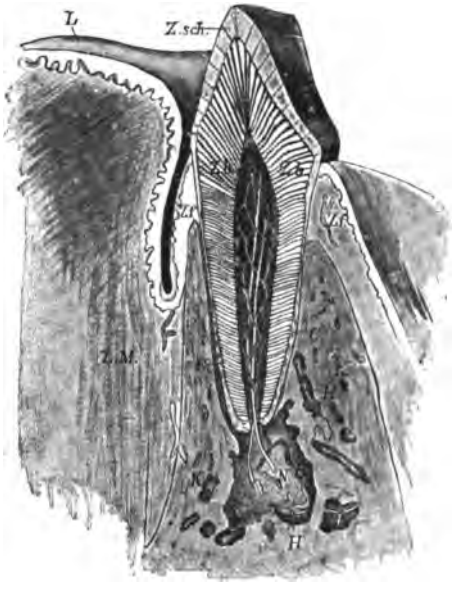
M., External ear, or pinna; G., external auditory meatus; T., tympanic membrane; P., tympanic cavity; G.K., auditory ossicles; eu.R., Eustachian tube; V., h.K. and Sch., portions of the labyrinth; N., auditory nerve.

(*b*) The *ear* is the organ of hearing. In most mammals external funnel-shaped projections, the *pinnæ*, are provided for catching the sound-waves. By the *external auditory aperture* these waves enter the ear *passage*, or *external auditory meatus*, the end of which is closed by a fine membrane, the *tympanic membrane*. The sound-waves induce vibrations in this membrane, which are transmitted to the *small bones of the ear* lying in the cavity of the tympanum, which is filled with air. A canal, the *Eustachian tube*, leads from the throat into the tympanic cavity, and thus establishes communication with the external air. The end of the innermost of the small ear-bones (stapes) is applied to a fine membrane of the *inner ear*, or *labyrinth*, which lies in a corresponding bony cavity. This membrane in its turn receives the vibrations and transmits them to a fluid contained in the *labyrinth*. Thence the vibrations reach the terminations of the auditory nerve, which expands within the labyrinth, whence they are conveyed to the brain, where they enter into the consciousness in the form of tones or noises.

Digitized by Google

(*c*) *Sensations of touch* are conveyed by the whole skin; as special organs of touch we may enumerate the tips of the fingers ~~(in man,~~ apes); the lips, with their special bristles ~~(examples ?)~~; ~~the trunk~~ (examples ?); the wing-membrane in bats; as well as the tongue (giraffe, cattle).

(*d*) The *nose* is the organ of smell. Its interior consists of large cavities lined by a membrane. Very fine rod-like terminations of the nerve of smell (olfactory nerve) project through the nasal membrane into the interior of the cavities, and are fanned and stimulated by the current of air which enters the nose during inspiration. This stimulus is transmitted by the nerve to the brain. To prevent the nerve terminations from drying up and becoming functionless, they are kept constantly moist by a mucous fluid secreted by the nasal mucous membrane. (It is impossible to smell when the nose is dry.)



SECTION THROUGH HUMAN INCISOR (LOWER JAW).

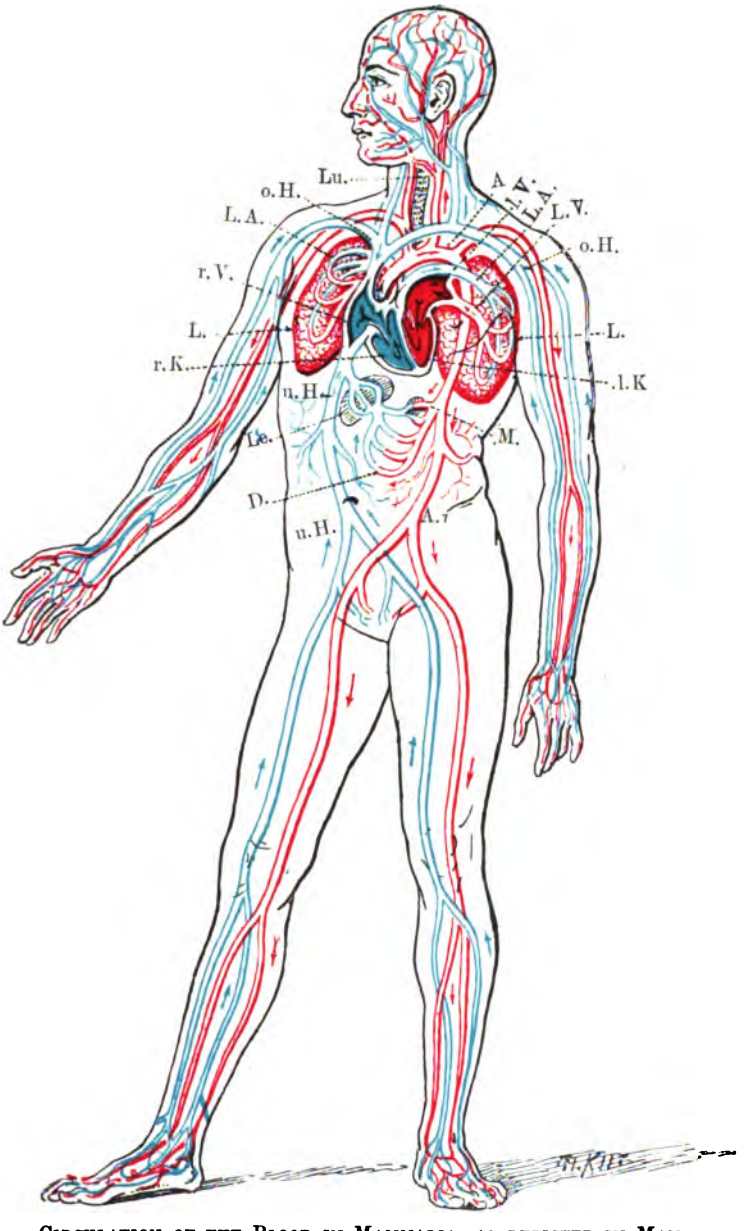
K., Lower jaw (mandible); H., cavities in the lower jaw, with parts of penetrating arteries; Zf., gum; L., lower lip; L.M., muscular fibres of the lip; Z.b., dentine; Z.sch., enamel; C., cement; N., nerve; B., bloodvessels which enter the dental cavity.

(*e*) The *tongue* is provided with organs of taste. Microscopically fine terminations of the nerves of taste (gustatory nerves) are chemically stimulated by sapid substances. These nerve terminations also require to be kept constantly moist (saliva).

4. **Teeth.**—Most mammals are provided with *teeth* in both jaws (see p. 11). These are fixed tightly in special pits in the jaws, the teeth sockets or alveoli. The portion of the tooth which projects freely from the jaws is termed the *crown*. If the part of the tooth which is embedded in the jaw is clearly distinguishable from the crown it is spoken of as the *fang;* if otherwise, the tooth is said to be *fangless*.

The teeth are composed of a hard bone-like substance, the *dentine* or *ivory*. The crown is generally covered by a material of glassy hardness, the *enamel* (*e.g.*, in man). Frequently, too, the enamel penetrates into

Digitized by Google



CIRCULATION OF THE BLOOD IN MAMMALIA, AS DEPICTED IN MAN.

The chambers of the heart and the vessels which contain arterial blood are coloured red, those containing venous blood blue. The gradual division of the great arteries into smaller and smaller vessels, and the origin of the great veins by the union of the smaller vessels (capillaries), is shown only in the head, hands and feet. The arrows indicate the direction of the blood-stream. Lu., Trachea; Le., liver; M., spleen; D., intestinal vessels. For the meaning of the other letters see Section 6.

Digitized by Google

the dentine in the form of folds, thereby imparting to the tooth surface the necessary roughness (as in the molars of Rodents and Ruminants). As a rule these folds are filled by a bone-like material called *cement*. This same substance in many cases also covers the fangs. The interior of the tooth is always hollow, forming a cavity which encloses the nerves and bloodvessels (for the nutriment of the tooth). The shape and formation of the teeth bear the closest relation to the mode of life of the animal, particular teeth, moreover, having special tasks assigned to them. (Division of labour. Give examples.)

5. **Respiration** is always carried on by means of lungs, and is performed by the action of special muscles. The most important of these muscles is the diaphragm, which in the form of a partition curving forwards (in man upwards) separates the thoracic from the abdominal cavity. When the diaphragm contracts, it becomes flatter, and so the cavity is enlarged, and air is drawn into the lungs (inspiration). Expiration is due chiefly to the contraction of the elastic pulmonary vesicles, which are dilated by the inspired air.

6. **The Heart.**—In mammals the heart shows its highest degree of development. By a longitudinal section it is divisible into two halves, each of which in turn consists of an anterior (auricle) and posterior (ventricle) cardiac chamber. The pure blood (in the pulmonary veins, L.V.), passing from the lungs (L.), enters the left auricle (l.V.), passes thence into the left ventricle (l.K.), whence it is driven (through the aorta, A.) over the body. After having traversed all the parts of the body and become richly loaded with carbonic acid gas, it returns to the heart (by the great veins, o.H. and u.H.), entering the right auricle (r.V.), and thence passing into the right ventricle (r.K.), whence it is pumped through the pulmonary arteries (L.A.) back into the lungs. *Thus by the division of the heart into two halves the arterial is completely separated from the venous blood.*

7. **The Urine.**—The urine, excreted by the *kidneys* in mammals, is conducted by two canals, the *ureters*, into the *urinary bladder*, which is periodically emptied by the contraction of its walls.

8. **Reproduction.**—With the exception of the Cloacalia (which see), all mammals bring forth living young, which, until they can feed themselves, are sustained upon the milk of the *mammary glands*. The openings of these glands generally lie upon wart-like elevations of the skin, the nipples or teats.

Digitized by Google

ORDER I.: APES (PITHECI).

FORE-LIMBS provided with hands, hind-limbs with prehensile feet, fingers and toes with flat nails. Eyes directed forwards, face more or less devoid of hairs. Live among trees and rocks. All are inhabitants of warm regions.

Orang-Utan (*Simia satyrus*).

(Height = about 4½ feet.)

A. Its Home.

The Malay name, "Orang-Utan" (*i.e.*, man of the woods), aptly designates this animal as a man-like inhabitant of the forests. Its home is in the well-watered, densely-wooded districts of Sumatra and Borneo. It frequents by preference the summits of the giant trees of the aboriginal forests.

B. A True Arboreal Animal.

1. *Hairy Covering.*—The whole body is covered with long shaggy hair. The only hairless parts are the ugly face, with its broad cheek callosities, its almost human ears, the huge neck-pouch, the hands and feet. All these parts are of a bluish-black colour.

(*a*) The colour of the hair is a reddish-brown, and very similar to that of the bark of the trees frequented by the animal, thereby proving an excellent means of protection, especially for the still defenceless young.

(*b*) In consequence of its semi-erect posture (see Section 3) the animal exposes its back to the rain; accordingly the hairy covering is much thicker on this part of the body than on the breast. As a protection against rain the shoulders and upper arm are similarly clothed with long thick hair. (Some of these hairs have been known to attain a length of from 16 to 20 inches.) The hairs of the lower arm (as in man) point towards the elbow. We are informed by naturalists, who have observed the animals in their native forests, that during rainy weather they will clasp hold of any tree branches that may happen to be above

Digitized by Google

them, or hold their hands over their head to ward off the rain from their body.

2. The Orang-Utan is a thorough adept in the art of climbing. According to one of its most careful observers, it moves through the densest forests with the same ease "as the Indian over the steppes or the Arab through the desert." (What renders the animal capable of performing these feats?)

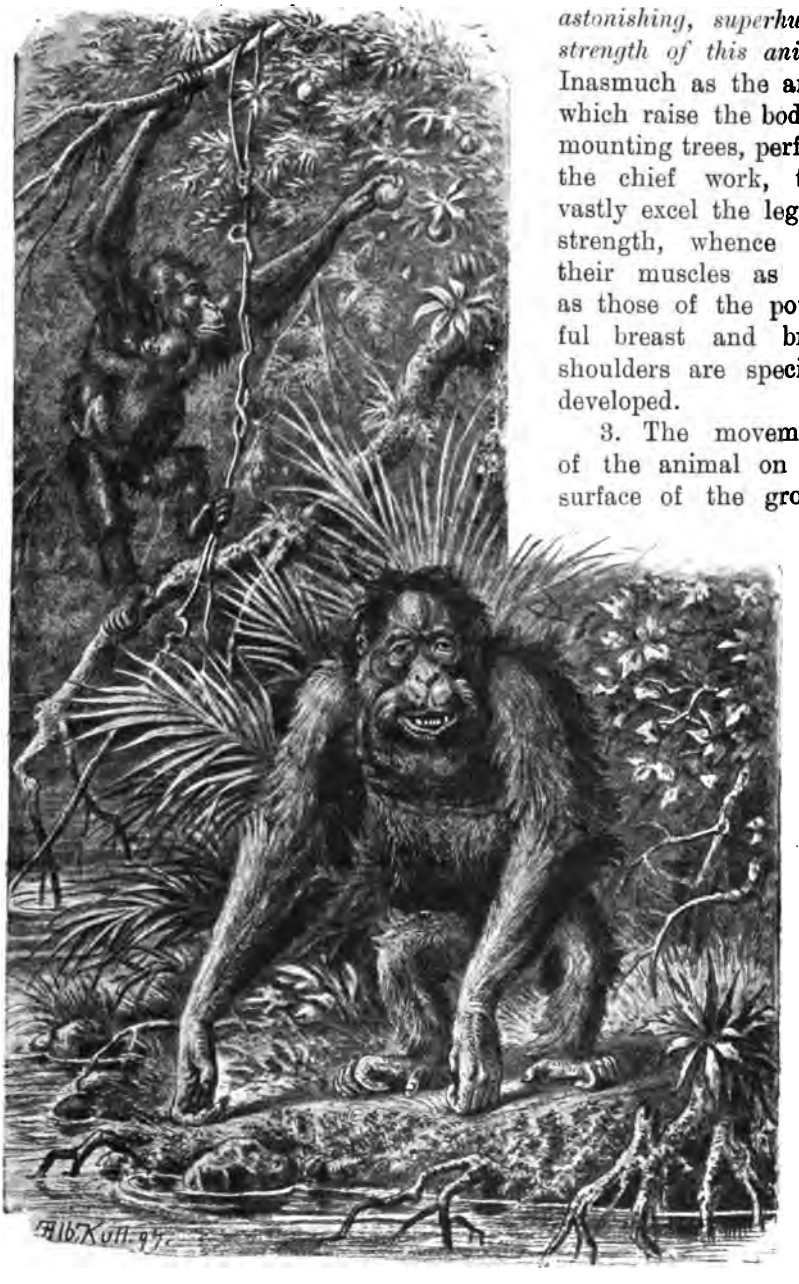
(*a*) The hands are very similar to those of man, but the thumb is shorter and the fingers much longer. Whereas the human hand is an almost perfect instrument for grasping (give proofs of this statement), that of the Orang-Utan is, in accordance with the arboreal life of the animal, specially adapted for climbing from tree to tree, the four fingers serving as hooks in this operation. By reason of their length the animal is able to obtain a safe and sure hold of branches of even more than usual thickness.

(*b*) The feet also are constructed on the plan of the hand; *i.e.*, the large toe is opposable to the other toes, just as the thumb is to the other fingers. The large toe is very strong, and can be widely extended (like the thumb in the human hand), and the soles of the feet are turned, not downwards as in man, but obliquely inwards. Consequently, in climbing the animal is able to grasp or embrace stems and branches with great surety, and can thus obtain a firm hold. These hand-like feet are of the greatest importance to the animal. For after having obtained a firm footing by their help, it has its hands free for the most varied kinds of activities, the seizing of food, care of its young, etc. It is, in the same manner, enabled to pluck leaves or fruit from branches which would not bear its weight.

(*c*) The arms are of great length, and by reason of the short legs, which, moreover, are never fully extended at the knee-joint, almost reach down to the feet. This great length of arm enables the creature to grasp branches at a great distance, to pluck fruit from the swaying summits of the trees and the ends of branches, and to lay hold of the boughs of neighbouring trees for the purpose of swinging itself on to them. If *one* branch is not found strong enough to bear its weight, the animal with its gigantic hands seizes hold of a whole cluster. The great length of the arm, further, enables the animal to walk down branches placed in a slanting direction. If its arms were not longer than those of man, it would, in consequence of the forward displacement of the centre of gravity, be exposed to the danger of falling (like a hare running downhill).

(*d*) Motion from one branch or one tree to another requires much greater strength than any movement on a level surface. *Hence the*

Digitized by Google



FAMILY OF ORANG-UTANS.
The male in the foreground (one-twentieth natural size).

astonishing, superhuman strength of this animal. Inasmuch as the arms, which raise the body in mounting trees, perform the chief work, they vastly excel the legs in strength, whence also their muscles as well as those of the powerful breast and broad shoulders are specially developed.

3. The movements of the animal on the surface of the ground

Digitized by Google

are very awkward, in consequence of its hand-like feet and the inward direction of the soles of the feet. Only the exterior margin of the foot comes in contact with the ground. To walk with surety the animal is obliged to support itself on its hands, or really upon the knuckles of the bent fingers. Hence its usual and most natural progress is on "all fours." The Orang-Utan, in fact, is adapted to *the one-sided existence* of an arboreal animal. (To how many-sided an existence, on the other hand, is man adapted structurally! Furnish proofs.)

The animal, however, is but rarely obliged to descend to the ground, for the trees of the aboriginal forest provide it with its necessary food, while the rain which falls daily in its home, as well as the moisture contained in the food, supply it with the necessary amount of water.

C. Food.

The exuberant forests which form its home supply the animal with food in the greatest abundance. It consists of young leaves, juicy buds, and all sorts of fruits.

1. Its *dentition* bears the closest resemblance to that of man. The four incisors, as well as the long dagger-shaped canines, by reason of their size, strength and sharpness, serve as an effectual weapon of defence (see Section D.). Powerful masticatory muscles enable it to bite with almost incredible strength.

2. The neck is short, the food being conveyed by the hands to the mouth. (Compare in this respect animals—*e.g.*, cattle, storks—which pick up their food from the ground.)

D. Enemies.

On account of its great bodily strength, only the crocodile and the python venture to attack it. We will relate in the words of a naturalist, who has carefully studied its mode of life and habits, how the Orang-Utan manages, as a rule, to get even with these foes. When the animal fails to find fruit in the jungle, it proceeds to the river-bank in order to feed on such young shoots and fruits as happen to grow close to the water. It is then that the crocodile tries to seize it; the ape, however, leaps upon it, beats it with hands and feet, tears its flesh and kills it, or tears open its jaws and throat. The python it seizes with its hands, and very soon bites it to death. Its powerful voice alone suffices to alarm the beasts of prey which infest the forests (compare the lion). In uttering its cries, the large neck-pouch is filled with air and acts as a resonator, thereby probably further increasing the strength of the voice.

The Orang-Utan does not attack man unless it has been wounded.

Digitized by Google

Unless under such conditions its pursuer is able to bring it down with a safe shot at a distance, he may give himself up as lost.

E. Family Life.

The female has only one young each year, which it nurtures with the greatest tenderness, and, in case of need, defends at the cost of its own life. The same maternal love, often even in an exaggerated form, we meet with in all the monkey tribe. Every evening the Orang-Utan builds a nest out of branches and leaves in the fork of a tree, in which it passes the night.

F. The Orang-Utan as compared with Man.

The Orang-Utan belongs to those apes which in their bodily structure approach nearest to man. It differs, however, from the latter in the following points, several of which have been already mentioned in our previous remarks:

1. The body is stouter and the belly more prominent. Its walk is never perfectly erect. 2. It possesses a neck-pouch and cheek callosities. 3. It has a coat of long hair. 4. The cranial cavity is extremely small, and the brain consequently but poorly developed. 5. The jaws are very prominent, almost like a snout; the facial angle, accordingly, in the adult only reaching 30 degrees. 6. The face is thrown into many folds, and the lips much swollen. 7. The canine teeth are very large, like those of the carnivora. 8. The nose is flattened, the nasal septum prolonged beyond the nasal wings. 9. The ears resemble those of man, but are placed higher up on the head. 10. Arms very long; the hands, with short thumbs, do not exhibit the fine structure of the human hand. 11. Legs short, with prehensile feet. 12. *It is, however, in its intellectual faculties, which (as is the case with all other man-like apes) are far inferior to those of the lowest savages (Papuans), as well as in the absence of an articulate language, that a wide gulf separates the Orang-Utan from man.*

This gulf is still further widened when we come to compare man with the lower apes, many of which have a long tail, cheek-pouches, anal callosities, etc.

Other Apes.

Family 1.—In all monkeys which inhabit the Eastern Hemisphere the nasal septum is narrow, so that the nostrils are open in front. They are hence designated **Narrow-Nosed,** or *Catarrhini*, or, according to their geographical distribution, as Old-World Apes.

(*a*) Among the **Man-like Apes** we class those of the Catarrhini,

Digitized by Google

which, like the Orang-Utan, use only the outer edge of their feet in walking, and have neither tail nor anal callosities nor cheek-pouches. To this group belong:

The **Gorilla** (*Gorilla gina*) and the **Chimpanzee** (*Simia troglodytes*). Both are inhabitants of the aboriginal forests of West Africa, and both in their structure and mode of life closely resemble the Orang-Utan.

The Chimpanzee reaches a height of only 5 feet, whereas the Gorilla generally surpasses man in weight, reaching a height up to about 5½ feet. Travellers describe it as a broad-shouldered, powerful animal of extraordinary strength.

(*b*) To the **Dog-like Apes** (*Cynopithecini*) belong those of the Catarrhini which have an elongated muzzle like a dog. Many of these have cheek-pouches (see Marmot), and a tail which is used as a rudder in jumping (see Squirrel); all have anal callosities, and walk on the soles of their feet.

To this group belong the **Baboons** (*Cynocephalus*). These are true terrestrial animals, inhabiting rocky and mountainous districts. Hence their body is much stouter than in the arboreal species; but they are nimble mountaineers, by reason of their short and powerful limbs. In correspondence with their habitat and structure, their food consists of bulbs and tubers which they dig up out of the earth, as well as of grass and all kinds of fruits growing on or a little above the soil, or such as have fallen from the trees. They also eat all kinds of insects and snails. All are ugly in appearance and of malicious disposition. The **Mandril** (*C. mormon*), whose home is in Guinea, with its yellow beard, blue cheek callosities, red anal callosities, and red nose, is the impersonation of repulsive ugliness.

The **Magot** or **Barbary Ape** (*Inuus ecaudatus*) is a tailless ape, which, being easily tamed, is trained by camel-drivers, bear-tamers, and in shows, etc., to perform all sorts of tricks. It inhabits the mountainous parts of Northern Africa, and is an excellent climber up cliffs and precipices, but will also mount trees. A few examples of this species occur on the Rock of Gibraltar as the sole representatives of the monkey tribe in Europe.

Family 2: New-World or Broad-Nosed Apes (*Platyrrhini*).—In this family the end of the nasal septum is thickened into a wedge-like shape, whereby the nostrils come to lie more at the sides of the face. They invariably possess a long tail, but never cheek-pouches or anal callosities.

The best-known members of this specifically numerous family are the **Howling Monkeys** (*Mycetes*). They are inhabitants of the aboriginal

Digitized by Google

forests of Brazil, and are clothed with black or brown hair, which furnishes a good fur. Their tail is as long as their body, very muscular, and naked below at the tip. As a prehensile organ it is without equal, serving, in fact, as a one-fingered hand. By its means the animal attaches itself to a branch, not letting go until it has obtained a sure hold with its hands. Suspended by the tail it swings and sways in the air, with its tail it fetches food out of clefts and chinks, and grasps or reaches any object. It has under its tongue a large bony drum, by which the voice of the animal is strikingly increased in force. The awful concerts performed by these animals in the morning and evening almost make one believe "all the wild beasts of the woods have suddenly risen in mortal combat with each other."

ORDER II.: LEMURS (PROSIMII).

FORE-LIMBS with hands, hind-limbs with grasping feet. All fingers with flat nails (like man), only the second toe with a claw. Face hairy.

In the order of Lemurs are contained a number of animals which in structure and mode of life present various differences, and which vary in size from that of a cat to that of a rat. They live in the tropical forests of the Old World, especially of Madagascar. Being true arboreal animals, they possess, like the apes (to which, however, they are not so closely related as the fact suggests), hands and prehensile feet; and their habits being nocturnal, their eyes are large, with very dilatable pupils (compare with owl and cat). They have a thick woolly fur, which protects the sensitive creatures from the penetration of moisture in the dew-drenched foliage of the forest trees. The most curious of all these animals is the **Spectre Lemur** (*Tarsius spectrum*) of the Sunda Islands. The enormous owl-like eyes, and the slender skinny hands and feet, with the pads beneath the finger and toe tips (resembling those of the tree-frogs), in fact, give the remarkable creature a somewhat ghostly appearance. Familiar denizens of Zoological Gardens are the ordinary **Lemurs** or **Fox-apes** (*Lemur*) from Madagascar, which have an elongated head like that of a fox.

ORDER III.: BEASTS OF PREY (CARNIVORA).

FLESH-EATING predatory animals with strong canine and more or less sharp-cutting molar teeth. Limbs with four or five toes, invariably provided with claws.

Digitized by Google

Family 1: Cats (Felidæ).

The Domestic Cat (*Felis domestica*).

A. Origin and Distribution.

Its love of warmth alone would seem to show that the cat is not a native of our climate (a probable descendant of the wild cat of our mountain forests), but a true child of the South. In Nubia, Abyssinia, the Soudan, and Palestine, it is still met with in a savage or semi-savage state, under the name of Desert Cat (*F. maniculata*). The ancient Egyptians early recognised the worth of this animal, regarding it as sacred, and embalming its body after death. Whcever killed a cat was punished with death, like an ordinary murderer. From Egypt the cat has spread almost over the whole earth, and is found wherever man has settled in fixed habitations, for the cat is more attached to its home than to its master. In the course of thousands of years its coat has lost the protective colouring of the desert possessed by that of its original parents, for, being now under man's protection, it no longer needs that of Nature. The colour of the skin is very variable, as is frequently the case with domestic animals, but never with those living in a state of nature.

The varieties of cats produced by breeding are not nearly as numerous as those of the dog (see under "Dog").

B. The Cat as Inmate of the House.

Every lover of Nature admires her slender graceful shape, her extraordinary agility in all her movements, her elegant accurately-aimed leaps, her great skill in climbing. Her confiding disposition and great cleanliness merit the favour of her owners. How carefully she cleans and licks her soft, thick, many-coloured fur! Every hair, from the head to the tip of the tail, is smoothed and arranged, every speck of dirt removed. Her excrement she carefully covers with earth. And what an attractive sight is a cat with her kittens, of which she usually produces two broods in a year, of four to six each! At first the kittens are blind, weak and helpless, and the mother nurses them, licks and cleans them, protects and guards them with devoted care. As they grow older we see her play with them, and give them lessons in their future occupation, so useful to ourselves, the catching of mice.

Many cats, however, are dainty, and fond of killing the feathered songsters of our gardens. This should be prevented as far as possible. The cat is sometimes said to be treacherous, because she scratches when she is tormented; but we defend ourselves when attacked, and the cat only does the same.

Digitized by Google

C. The Cat as a Zealous Destroyer of Vermin.

As a killer of rats, mice, etc., the cat is unexcelled. The pursuit of these is carried on specially at night, and it is astonishing what numbers of these troublesome rodents a cat manages to destroy. It has been shown that a cat just above half-grown can devour 20 mice a day, or 7,300 a year. Three thousand six hundred and fifty, or a corresponding number of rats, is considered a moderate annual amount. Frequently, indeed, the mere presence of a cat is sufficient to drive out the insolent rodents; for if they do not depart of their own free will, the cat manages to get rid of them "in another way." It has, indeed, frequently been noticed that a cat will kill far more mice than it can eat. When hard pressed it will also consume grasshoppers, cockchafers, frogs, and snakes, including the poisonous viper, and has even been known to kill rattlesnakes.

D. How the Structure of the Cat is adapted to a Predatory Life.

Both by the acuteness of its senses, the form and structure of its body, and its intellectual faculties the cat is eminently fitted for its murderous vocation. All these faculties are well displayed from the moment it catches sight of its prey, up to the seizing, tearing, and swallowing of it.

i. How the Cat becomes aware of its Prey.

1. Snugly rolled up, so as to offer the least possible cooling surface, we observe our cat lying asleep by the warm hearth. Suddenly it rises, and, with its belly almost brushing the ground, creeps towards some cupboard, press, or the like in a corner. Here it stands watching immovably still, and frequently, before even a few minutes have passed, will be found with a mouse struggling within its paws. Thus, even while asleep the cat must have heard the noise made by the mouse, which no human observer could have detected; it was able to discern the nature of the noise (viz., that it proceeded from a mouse), and to form a correct judgment of the direction and distance from which it proceeded. We thus learn that the cat is possessed of an uncommonly *fine sense of hearing*, as is further indicated by the *movable muscles of the ear*.

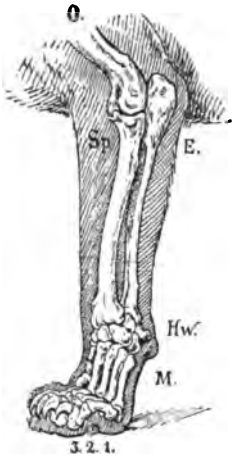
2. The *eyes* are large and *sharp-sighted*. The cat is able, as a protection against a too brilliant light, to contract the pupils of the eye until they form a narrow *vertical* slit. As it gets darker and fewer and fewer light rays enter the eye, the pupil correspondingly dilates. In the dusk it is almost circular.

3. On perfectly dark nights or in very dark places cats can no more

Digitized by Google

see than man.* It is then guided by another sense, a *fine sense of touch*. This has its seat especially in the roots of the long hairs of the upper lip. If one of these hairs be only quite gently touched, the animal at once shrinks. If these hairs are cut off, the cat becomes restless and unsteady in its gait. It displays the same sensitiveness in the long hairs over the eyes, and, indeed, in the whole of its body. (If its skin be stroked backwards—as is often done in the dark to draw electric sparks from it —it will violently defend itself.)

4. The sense of smell, on the other hand, is somewhat dull. Some cats, indeed, can at once smell when milk is brought for them, without previously having seen the saucer; others, again, will not even perceive a mouse hidden in the hollow of one's hand until it is pushed close under their nose.



FORE-LEG (ARM) OF CAT. (M.) O., Humerus; Sp., radius; E., ulna; Hw., carpal bones; M., metacarpals; 1, 2, 3, digital joints or phalanges.

ii. Method of capturing the Prey.

1. On perceiving its prey, the cat rushes upon it with long leaps, crouches down, and after one last leap seizes it with the sharp claws of its front-paws; another manner of capturing the prey consists in gliding up close to it, with the body almost brushing the ground, and then suddenly pouncing down on it. *The cat walks with extreme silence*, as if wearing felt slippers, and its progress is quite inaudible. It can thus approach its prey unobserved. It touches the ground only with its toes (digitigrade), beneath which are soft balls or pads covered with short hairs, and these suppress the sound of the tread (velvet paws).

2. As mentioned above, the cat pounces upon her unsuspecting prey by powerful leaps. Also when pursued by other animals or by man, she flees in a succession of bounds, which are often 3 or 4 yards long or high. For these astonishing leaps she is adapted by—

(*a*) The bent portion of the elbow-joint in the fore-leg, of the knee and ankle joints in the hind-leg (compare a cat's skeleton with that of a horse or ox). The body is projected by the sudden straightening of the legs.

(*b*) The great length and muscular power of the hind-legs, reaching far forwards beneath the body.

* The shining of cats' eyes in the dark is not due to light rays proceeding from their eyes, but to a reflection of rays (however few) entering the eye, from a membranous layer within the eye (the tapetum).

Digitized by Google

(*c*) The extraordinary elasticity of the body. If we bend a rod of cane or steel, hold the two ends together, and then let them go suddenly, the rod springs away a considerable distance. The flexible and elastic backbone of the cat works exactly like such a rod. This peculiarity of the body, together with the flexible joints of the legs, is of service to the cat in another way. When seized by an enemy, man or dog, she can turn round either fore-part or hind-part of her body, and so make use of her principal weapons, the claws. The slender flexible body also facilitates climbing, and enables her to creep through chinks and crevices (see Section *e*); and lastly, by skilful contortion of the body, she is able, even from a moderate height, to fall always on her feet. (Why is this more difficult than when she falls from a greater height?)

(*d*) The long, powerful tail, becoming somewhat weaker towards the end, which (in springing as in falling) serves as rudder.

(*e*) The absence of the clavicles. When a man in falling tries to support himself on his arms, he may easily break them; for as he possesses clavicles, and needs them (see p. 11), his arms are firmly (without elasticity) connected with the shoulder-girdle, so that the shock in falling is not diminished. The cat, on the other hand, at every spring alights on the fore-legs. Fracture, however, does not take place, because the shoulder-blades are only connected with the skeleton of the trunk by ligaments and muscles, and yield to the shock (prove on the living animal how easily the shoulder-blades can be moved), and also because yet another safeguard occurs in the shoulder-joint. When the weight of the body comes on the fore-legs, the angle between the upper arm and shoulder-blade is diminished, enlarging again when the bones return to their resting position. (Hence we understand why all swift-running and springing animals have no clavicles.)

The absence of the clavicles also enables the cat to compress the fore-part of the body in creeping through holes which are apparently much too small. Any hole is big enough if her head will pass through.

3. The last joints of the toes are provided *with curved claws, the points of which are of needle-like sharpness*, and which penetrate the body of the prey like daggers. To prevent these murderous weapons from becoming blunt by contact with the ground, they, as well as the last joints of the toes, are bent upwards in walking, and concealed in a fold of the skin like a dagger in its sheath. They are held in this position by the tendon of a muscle and two strong elastic bands. If the animal, however, is roused or about to seize its prey, two flexor muscles, the tendons of which are attached to the under side of the two last joints, with lightning-like rapidity pull down these joints and the sickle-shaped claw, thus converting the foot into a terrible weapon of attack. With the cessation of this

Digitized by Google

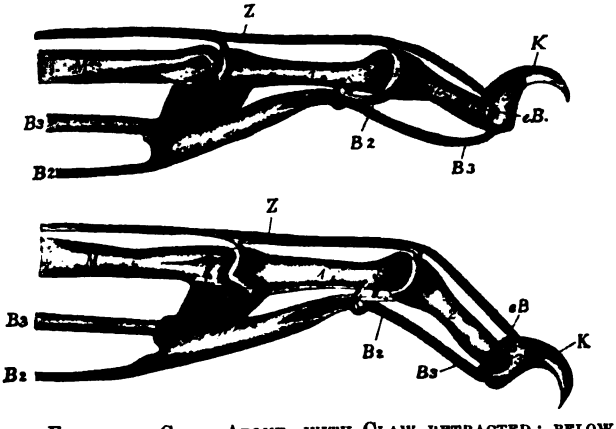
contraction of the muscle, the tendon and elastic bands mentioned above draw back the joints of the toe and the claws into their original position.

The flexible legs and sharp claws also enable the animal to climb up high objects, such as trees, walls, etc., with ease and safety, and thus aid it in the pursuit of birds. Finally, the sharp claws serve it as a much-dreaded weapon of defence against its enemies (dogs).

iii. How the Killing, Tearing-up, and Consumption of the Prey are effected.

1. Holding its victim tightly in its claws, the cat soon kills it with a few powerful bites, the long and pointed *canine teeth* entering the flesh like knives, and inflicting almost instantaneous death. Overlapping each other, and thus forming pincers, as it were, these teeth hold the prey tight, and prevent it from escaping.

2. (*a*) The *molar teeth* form excellent instruments for tearing the prey



TOE OF THE FOOT OF A CAT. ABOVE, WITH CLAW RETRACTED; BELOW, WITH CLAW PROTRACTED. (AFTER GRABER.)

M., Metatarsal bones; 1, 2 and 3, first, second and third digital joints; Z., tendon of the muscle (which lies higher upon the foot) which effects the retraction of the claw; eB., elastic band; B_2, tendon of the muscle which bends the second digital joint; B_3, tendon of the muscle (penetrating through B_2) which effects the flexion (protraction) of the third digital joint and the claw.

into pieces. Behind the canine teeth on each side above and below are two smaller teeth, which end in several sharp points. They are called *premolars*. (Why?) They bite edge to edge in such a manner as to tear up and mangle the prey. Behind these rises the strongest and most formidable of the set, the so-called *carnassial tooth*. It possesses a double-pointed cutting-edge. In closing the jaws the upper carnassials glide closely along the outer surface of the lower ones, and in this way form the *saw-like blades of two pairs of shears, as cutting as instruments of steel.*

Digitized by Google

(*b*) The dentated edges of these shear blades prevent the object to be cut up from *slipping out.*

(*c*) As the premolars fit into each other and the carnassials glide past each other, the crowns of these teeth do not wear away (as in herbivorous animals), and the teeth, so far from becoming blunt, *actually sharpen each other mutually.*

(*d*) The position of the *carnassial* teeth far *back* in the *short jaws, i.e., on the much shorter arm of a lever,* still further intensifies their action. For, by the principle of levers, the shorter the arm on which the load acts, the greater is the effect of the power. Owing to the shortness of the jaws, the other teeth also rest on the short arms of levers, and can accordingly exert a powerful action. The *rounded, globose head* of the cat therefore stands in the closest relation to its mode of life. (Compare the head of an ox.)

(*e*) To keep the blades of the shears in a position most effectual for working, it is necessary that the shears be tight in their rivet. Conse-

SKULL OF DOMESTIC CAT. (One-half natural size.)

quently the joints of the *lower jaw are very firm.* Their sockets are deep transverse grooves, in which the roller-shaped heads of the mandible can only turn about their axes. The mandible is thus only capable of an up-and-down motion, not of a lateral or forward movement, as is the case in ruminants and rodents (which see).

3. Behind the upper carnassial teeth we find on each side a small tooth with blunt prominences (molar tooth), which, as its grinding surface shows, serves to crush the food. An inwardly directed *projection of the upper carnassial* has a similar signification.

4. These arrangements, however, are not sufficient for the thorough rubbing or crushing up of the food (see Section 9). In its tongue, which is provided with many sharp, backwardly-pointed spines, the cat possesses an additional instrument of attrition. Indeed, it furnishes the mouth with, as it were, an additional weapon. (Thus, the largest of the cats, the lion, can by repeated licking cause the skin of a man to bleed.)

5. The *incisors,* as one might gather from their small size, are not

Digitized by Google

used for biting off large pieces of flesh, but merely for gnawing the bones.

6. The *mouth* forms a *wide cleft*, as may be seen when the animal is yawning. This enables it to drive the canine teeth deep into the flesh of its victim, to carry it off (see Section 8), and to tear it in pieces.

7. The work of the canine teeth and molars is carried out by *very powerful muscles*. The mouth being very wide, the masticatory or jugal muscles, though powerful, are not nearly so large as in rodents (which see). On the other hand, the *temporal muscles* are strongly developed. Their surface of attachment is enlarged by the development from the middle of the parietal bone of a high bony ridge or crest, which is continued into two lateral ridges in the occipital region. The *jugal arches* have a wide sweep in order to provide space for the lower parts of the strong temporal muscles and the strongly developed *coronal processes of the mandible*, to which the temporal muscles are attached.

8. The cat prefers to consume its prey in a safe place where it may not be disturbed by intruders; moreover, in its former wild state it used, as cats who have run wild do still, to kill animals of considerable size. Accordingly, it is provided with a *strong neck*, which enables it to carry its prey for considerable distances in its mouth.

9. The cat is not obliged to grind down its food as finely as, *e.g.*, a ruminant animal. (Why is this not necessary? See ox). The *œsophagus is accordingly of great width.*

10. Animals of smaller size are consumed bones and all; consequently the *gastric juices* needed for the solution and digestion of such harder materials are in the cat *very acid.*

11. The food of the cat is of highly nutritious quality, and *the intestine accordingly short* (see ox).

E. The Mental Faculties of the Cat adapted to its Predatory Mode of Life.

To succeed in the pursuit of its prey, the pursuer must excel its victim, not only in bodily strength, but also *in mental qualities.* The cat displays *courage* in defending itself against even the largest dogs; *patience* and *calmness* when it sits for hours motionless in front of a mouse-hole. With great *cunning* it allows the mouse to slip out of its safe hiding-place, and with *accurate judgment* it chooses the right moment for making the decisive leap. However, in discussing the mental characteristics of the cat, we must not omit to mention its *cruelty* and *bloodthirstiness.* It does not kill its victim outright, but allows it to run for some distance, seizes it again, and repeats this performance for an indefinite time, till finally

Digitized by Google

it ends its agony with one powerful bite. If the prey should happen to escape, the cat does not continue the pursuit.

Other Members of the Cat Family.

Apart from small deviations, all the species of the cat family resemble the domestic cat in structure, habits and mode of life.

The **Wild Cat** (*Felis catus*) and the common **Lynx** formerly occurred in Germany, the latter being now extinct, but the former still inhabiting the woods and forests of mountainous districts. The wild cat is larger and stronger than the domestic cat; its coat, in accordance with its nocturnal mode of life, being gray with black stripes, gray being a colour which most easily escapes notice in the dark. The tail is of uniform thickness, not tapering like that of the domestic species, and the posterior third of it is marked by black rings. The wild cat, being a destroyer of all sorts of small birds, of pheasants and hares, of the fawns of red and roe deer, is an object of special aversion to the sportsman. To the farmer and forester, on the other hand, it is useful, being a zealous destroyer of mice. It kills more than it is able to consume, and has therefore with reason been described as "a tiger in miniature."

The **Lynx** (*Felis lynx*) was still to be found abundantly in the Middle Ages in all the larger forests of Germany. It is now quite exterminated in that country, but still to be met with in the Alps and Carpathians, in Scandinavia, Northern Russia, and Siberia. The animal reaches a length of about 4½ feet, and is very destructive in game preserves. In the pursuit of its prey it is aided by the colour of its skin, which almost exactly resembles that of bark or of lichens. The ears are tipped with long pencils of black hair.

The Lion (*Felis leo*)—1. *Distribution.*—The lion is an inhabitant of the whole of Africa and a large part of Western and Southern Asia. Formerly, as we learn from the Bible (Samson, David), it was found also in Palestine, and even in Greece (Hercules). It is, however, unable to withstand the progress of civilization, and its ranks have become remarkably thinned since the invention of firearms.

2. *Structure.*—On account of its size (up to 3¼ feet in height at the shoulders), its noble shape, majestic bearing, fine and powerful head, broad chest, slender body, the immense power of its paws and teeth, it has been termed for ages past "the king of beasts." The body is covered with thick short hair, varying in colour from a light yellow to a dark brown, and assimilating to the colour of the desert, along the margins of which it has its habitat. A huge, sometimes darker-coloured

Digitized by Google

mane overhangs the breast and shoulders of this noble creature like a royal mantle. The tip of the tail is ornamented with a tuft of hair.

3. *Mode of Life.*—Like all cats, the lion spends the day in idle repose, lying asleep in a pit dug out by himself or in some protecting thicket; but after sunset, when the bright stars of the tropical sky shed their soft light upon the sleeping earth, he rouses himself for his murderous vocation. "With a thunderous roar he announces his setting out for the nightly hunt; all the other lions who hear the sound from afar reply in concert, but all other animals are seized with fear. The howling hyæna grows dumb; the leopard ceases its growling; the monkeys begin to utter gurgling sounds, and fly terror-stricken into the highest branches; the lowing herd becomes silent as death; the antelopes in mad flight burst through the bushes; the camel trembles under its load, and, ceasing to obey its driver's voice, throws load and rider off and seeks safety in speedy flight; the horse rears and snorts, and with inflated nostrils rushes away; the dog, fawning, seeks protection with his master; and even the man on whose ears falls for the first time the voice of the lion in the aboriginal forests questions whether he be bold enough to meet the creature that sends forth such thunderous tones."

The lion frequently prowls in the neighbourhood of a native kraal, a white man's farm, or the camps of hunters and travellers, and seizes horses and cattle. The immense muscles of the animal's jaws, shoulders and forelegs give it enormous strength. It is able to drag an animal of the size of a buffalo or an ox for a considerable distance, although incapable of lifting such a carcase entirely off the ground, but when undisturbed will feed where it has killed its prey. Its spring carries its heavy body for several yards, and it leaps over a palisade without difficulty. It can gallop with great speed, and when enraged has often been known to overtake and pull down a fast horse urged by his rider to his utmost effort. Experts tell us that a single lion in one year can inflict damage to the amount of two or three hundred pounds. Little wonder that so fierce a bandit is relentlessly pursued, and, in fact, in the more settled regions of South Africa the lion has been exterminated.

In districts where no cattle are reared the lion obtains its food in a different manner. Where some murmuring brook breaks through the desert sand or the hard soil of the sun-burnt steppe, safely hidden in the thicket, he lies in ambush for the beasts of the desert—the fleet antelope and gazelle, the giraffe and the zebra. Woe to any creature that approaches *with* the wind! Scarcely has it bent down "to cool its parched, loose-hanging tongue in the waters of the lagoon," when forth springs its terrible foe. Under the gigantic weight of its fierce rider (up to about

Digitized by Google

300 pounds) the victim collapses powerless, and soon gives forth its last breath under his terrible claws and teeth.

Man, however, by his lofty bearing, and especially by a sure and steady look, inspires even the lion with respect. With shy mien the "king of the desert" makes way for the "lord of the earth." On the other hand, after he has once discovered man's real physical weakness, he prefers human flesh to any other food; in the words of the Kaffirs, he becomes a "man-eater."

The **Tiger** (*Felis tigris*) inhabits all the countries of Asia, from the

ROYAL TIGER IN THE JUNGLE. (One-thirteenth natural size.)

Sunda Islands to the Amoor, and from the shores of the Pacific Ocean to the foot of the Caucasus. The farther to the north it lives, the thicker is its fur. Its favourite haunts are swampy districts of the tropical zone thickly overgrown with bamboo and similar bushes. The magnificent colouring of its coat appears very conspicuous; this, however, is not really the case, for, according to the unanimous reports of travellers, it so closely assimilates to its surroundings that one of these robbers lurking quietly in the jungle frequently escapes the eye even of an experienced hunter. The red or yellow ground colour of the body

Digitized by Google

corresponds with the tint of the decaying leaves and stalks which thickly cover the ground, while the dark striped shadows of the reeds and cane-stalks are mirrored in the black transverse stripes of its skin (in fact, the tiger is a kind of "living trap"). It is not inferior to the lion either in size or strength, while in courage and ferocity it even surpasses the "king of beasts." The tiger seeks the neighbourhood of man, and in many parts of India has become an actual plague, causing the inhabitants to leave their homes, and even depopulating whole districts. Thousands of human beings even up to the present day still perish annually under its terrible claws and powerful teeth.

The Leopard (*Felis pardus*).—The skin of this animal is ochre yellow, ornamented with many smaller or larger black annular spots. When reposing in the thicket of the forest or lying in wait for his prey, this "spotted skin" so exactly imitates the play of the sunbeams and the circular shadows of the leaves, that even the sharp eye of the hunter fails to detect the animal. The leopard is a formidable enemy to all mammals, and even man. Its true home is in Africa. The Asiatic species is known as the **Panther.**

The **Jaguar** (*Felis onca*) and the **Puma** (*Felis concolor*) are the two largest representatives of the cat family in the New World. The skin of the former is from yellow to nearly black with dark annular spots, "reflecting, like that of the leopard, the variegated forests of its home." The skin of the puma is of a uniform grayish-brown. The depredations of these animals among the herds make them the worst foes of the settler. Like its nearest relatives in the Old World, the jaguar also is a "man-eater."

Family 2: Hyænas (Hyænidæ).

The Striped Hyæna (*Hyæna striata*).

(Length about 3½ feet; height at shoulders about 2½ feet.)

The yellowish-gray skin with black transverse stripes of the hyæna points it out as a nocturnal animal (compare with wild cat, p. 31). A bristly, erectile mane surmounts the nape of the neck and the sloping back. The teeth are of the carnivorous type. The front-legs however being much longer than the hind-legs, the animal is unable to run either rapidly nor for any considerable time (like the dog), nor is it able to creep or spring (like cats), consequently the hyæna can only seize upon animals that are sick or those which are unable to defend themselves (sheep, goats, etc.). As a rule, it has to be content with carrion, which, owing to its exceedingly fine sense of smell, it can scent from a great distance. The

Digitized by Google

powerful skull, short jaws, and strong teeth point to an extraordinary power of mastication. The hyæna, indeed, is able to crush bones which even resist the lion's jaws. This faculty enables it to make use of the remains of the meals of other carnivores.

When complete darkness has set in, these animals leave their caves and go in packs in search of carrion. For the purpose of keeping together they set up an abominable howling. As soon as they have discovered the spoil, the hideous concert ceases and the loathsome feast begins. They are the true "vultures" (which see) among mammals. They will even dig up human bodies which have been buried near the surface. To man they are an object of special aversion by reason of their hideous shape, their disagreeable voice, their dreadful cowardice, their loathsome smell, and the depredations they commit among the herds. Their home is in Africa and Western Asia, where there is never any dearth of carrion.

The Spotted Hyæna (*Hyæna crocuta*).

The spotted hyæna, the skin of which is dotted over with dark spots, is an equally repulsive creature. It is found in South and East Africa. When famished, it will even seize children and attack sleeping or exhausted men.

Family 3: Dogs (Canidæ).

1. The Wolf (*Canis lupus*).

(Length of body about 4 feet; height at shoulder nearly 3 feet.)

A. Structure and Mode of Life.

1. The *coat* of the wolf is thicker and longer in Northern districts than in the South. Its colour is gray or blackish, like that of the soil. In Northern countries the white predominates; in the South the black. The summer coat is always darker than the winter coat. The tail is covered with bushy hair.

2. It is possessed of an extraordinarily fine sense of smell, which it employs in the scenting out and pursuit of its prey. By its help it discovers an animal even at a great distance, and the least possible trace of scent which may cling to the ground serves it as a sure guide to its victim.

The nostrils are wide and the nasal muscles very large, which enables it to examine large quantities of air for odoriferous substances. The nose is always kept *moist*, since odours cannot be perceived when the nose is dry.

3. Though the sense of hearing is less acute than that of smell, it is

Digitized by Google

nevertheless sufficiently keen to perceive sounds which are to us inaudible. The ears are accordingly pointed and very movable. The sight, too, is excellent.

4. The wolf pursues its prey *running;* in fact, it hunts it. In a single night it can easily accomplish a distance of forty miles. Let us examine what bodily arrangements render the animal capable of such a performance.

(*a*) The body (vertebral column) is not nearly as flexible as that of the cat, and, being laterally compressed, offers less resistance to the air. While running swiftly the head is stretched forwards, thus forming, as it were, the point of a wedge. (Any cyclist will tell us that the air offers great resistance to a swiftly-moving body. When riding fast, especially if against the wind, the rider bends his body forwards, so as to offer the smallest possible surface to the air.)

(*b*) Only its *toes* touch the ground in walking or running. Animals which walk on their toes, however (Digitigrades), are lighter-footed and swifter than those which walk on their soles (Plantigrades). The former raise their feet from the ground with ease, whereas the latter roll them, as it were, from the heels to the toes.

(*c*) The *legs are long*, only *slightly capable* of *lateral motion* (their joints being less movable than those of the cat), and but little *bent;* hence they are well adapted to swift running. (The feet of the wolf, accordingly, are of no use for creeping, climbing, seizing and killing of the prey, but are only useful for keeping a tight hold of the prey while it is being consumed.

(*d*) By means of its short, blunt, non-retractile *claws* and the thick *pads* on its toes it is able to plant itself firmly against any unevennesses of the surface.

(*e*) Every powerful movement has the effect of raising the body-heat of an animal. Accordingly, there is a considerable rise of the body-temperature of the wolf during a swift run. A rise of the body-temperature, if at all prolonged, is, however, injurious to an animal, especially a mammal, so that it is necessary that the *temperature should be speedily brought back to the normal.* This is generally effected by the secretion of sweat, in the evaporation of which any excess of heat is withdrawn from the body. But since the skin of the wolf (as well as of the dog) possesses no sweat-glands, this reduction of heat must be brought about by other means. The "panting" of a dog, who is nothing more than a descendant of wolf or jackal (see p. 38), when running fast, is a matter of common observation. It is not noticeable to anything like this extent in other mammals under similar conditions, *e.g.*, a fast-running horse. Whereas a dog, while resting or running slowly, only takes from twenty

Digitized by Google

to thirty breaths in the minute, in running fast this number is increased to from 300 to 350. We observe exactly the same in its ancestral parent the wolf. This accelerated respiration, however, causes the removal of a large quantity of water from the lungs (about 4½ ounces per hour in a dog of middle size), and by the rapid evaporation of this water, just as by the evaporation of the sweat from the skin, a considerable cooling of the body is effected.

(*f*) By means of the sweat, moreover, a large number of waste products are removed from the body. In the wolf (or dog), which, as we have mentioned, has no sweat-glands, this function is undertaken by the kidneys. This explains the frequent *passing of urine* indulged in by wolves and dogs.

5. In its *dentition* the wolf very nearly resembles the cat (which see). The jaws are more extended, and lodge a greater number of molars, which, though less sharp, are stronger than those of the cat, so that the wolf (and dog) is able to crush the bones of even large animals. On each side of the upper jaw there are three *premolars*, and four on each side of the lower jaw. The true molars number two on

SKULL OF A WOLF. (One-fourth natural size.)

each side of the upper and lower jaws. These, like the posterior portion of the lower carnassial tooth, have broad crowns for crushing and grinding up the food. The structure of the teeth enables these animals also to consume vegetable substances (potatoes, corn-cobs, etc.); they (and their relatives), accordingly, are not quite so ferocious and bloodthirsty as the cats, and their *intestine* is somewhat longer than that of the latter. What has been said in regard to the *canine teeth* and their importance, the *articulation of the mandible*, the *jugal arches*, *parietal and occipital crests*, *width of the mouth*, and *acidity of the gastric juice* in the cat applies equally to the wolf and its congeners.

6. Like all beasts of prey, the wolf is *sly*, *cunning*, and *cautious*. To make its hunts more successful, it unites with others of its species into a pack. With one bound it leaps at the throat of larger animals (cattle,

Digitized by Google

horses, goats, deer, etc.), which it tears open with one bite. The animal thus attacked then bleeds to death from the carotid arteries.

B. Distribution of the Wolf, and Damage inflicted by it.

The wolf is met with throughout the whole of Europe, Northern and Central Asia. Even at the present time it is frequently met with in France, Spain, Italy, the greater part of Austria, Hungary, the Balkan States, Russia and Scandinavia. In Germany it is now quite extinct; but examples from France and Russia are still met with annually in the border districts. It frequents, by preference, mountain ranges, dense woods, swampy districts, and wide steppes. As the body is kept constantly in motion in the pursuit of the chase, the wolf requires a large quantity of food, and, moreover, slays many more animals than it actually needs for its nourishment. Accordingly, it is a great scourge to cattle-owners and hunters, who wage constant war against it. A single wolf in the neighbourhood of Schliersee and Tegernsee in Upper Bavaria is recorded to have made away with about 1,000 sheep in the space of nine years, apart from game, the number of which could not be determined. In winter, when suffering from hunger, wolves will even attack human beings.

The **Jackal** (*Canis aureus*) is a near relative of the wolf. It is found in Asia, North Africa, Greece, Turkey and Dalmatia. The "fox" mentioned in the Bible as having served Samson in burning the fields of the Philistines was probably a jackal. These animals also hunt in packs. Their plaintive howls, "making night hideous," and their daring thefts, make them everywhere an object of special aversion.

2. The Dog (*Canis familiaris*).

A. Origin and Varieties (Breeds).

The dog is the descendant of various species of wolf and jackal which are still met with in various countries. Indeed, the resemblance between the dogs of savage tribes and the wolves or jackals occurring in those districts is so great that they have often been mistaken for one another.

Man, by occasionally taming them, came to recognise the good qualities of these animals, and subjected them to his service. From their descendants he selected invariably the fittest, and thus, by continuous breeding and training, extending over perhaps thousands of years, the dog has been evolved from the wolf or jackal.

Digitized by Google

"Use for a definite purpose" has been man's guiding principle in the breeding of the different races of dogs. Thus, if he required an assistant in the chase, he would take with him the dog who had the "best nose." From the descendants of this animal he again selected those endowed with the keenest scent, and so, by degrees, the *pointer* was developed. In this selection, however, whim, inclination or a predilection for particular forms played a secondary yet by no means inferior part. Thus, if he took a special liking for long-haired dogs, he would devote special care to such, always selecting from their descendants those with longest hairs for further breeding. Thus in the course of some thousands of years our *poodle* may have come into existence. *By means of this constant selection the development of all our various breeds of dogs may be explained, as well as the varieties of all our other domestic animals, and exactly the same method is still employed at the present day.*

Man even went so far in this process of selection as to breed races endowed with qualities actually disadvantageous to the animals in a wild state, races which, without his protection, would be able to sustain themselves with difficulty or not at all. Thus, we have breeds of dogs with long hanging ears, with their lower jaw projecting far beyond the upper (bulldog), with curled-up tails, etc. When such dogs, however, return to a state of nature and are obliged to seek their own food, they lose these disadvantageous characters. Their descendants again come to resemble the original parent stock. The semi-savage dogs of Eastern countries and the dingo of Australia (which is also a dog returned to the wild state) have again, in the course of time, acquired erect ears, pointed muzzles and extended tails. The number of dog varieties is uncommonly large. We are all acquainted with the crooked-legged dachshund, the fleet-footed greyhound, the gentle Newfoundland, the snarly bulldog, the watchful sheepdog, the lazy pug, the powerful mastiff, the tiny little lap-dog, the clever poodle, the faithful Pomeranian, the keen-scented *sporting* dog, and many more.

B. The Dog as the Friend and Helpmate of Man.

Wherever on the earth we find man, there too we meet the dog. The services it renders to man are as numerous as are the breeds of this animal. Now acting as a faithful guardian of house and hearth; now as a careful protector of the flock; an untiring attendant of the chase after every kind of game, and the most inveterate enemy of its own nearest relations, the wild species of the dog and cat families; a good-natured playmate of the children and the faithful companion of its master. It even submits patiently to be harnessed to a cart, although its movable

Digitized by Google

toes offer but little resistance in drawing a load (compare, on the other hand, the horse). On behalf of its master it will risk its own life, and there are many cases in which it has saved human beings from a certain death. Take, for instance, that of Barry, the famous St. Bernard, who alone rescued no less than forty human beings from perishing in the snow. To the Eskimo the dog is as indispensable as the reindeer to the Laplander, while the semi-savage dogs of the East act as a kind of sanitary police by at once consuming all domestic refuse, and thus preventing it from putrefaction. Unshakable affection, fidelity and attachment, unconditional obedience, the utmost readiness for every service and the most complete devotion—these are the qualities for which the dog has almost become proverbial. On the other hand, if attacked by hydrophobia, the dog may become an object of danger even to its master; nor is it always safe to allow one's self to be licked by a dog, or to go so far as to kiss it, since in this manner the ova of a tape-worm peculiar to this animal (which see) may be easily conveyed to man.

C. The Anatomy of the Dog in Relation to the Services which he renders to Man.

The anatomy of the dog in its most essential features agrees with that of its ancestral parent.* Such deviations as occur are the result of breeding and training extending over a long period of years.

1. The dog, being under the protection of man, requires no protective colouring. Consequently the colour of the *skin* is variable.

2. The sense of *smell* is of astonishing acuteness. As is proved by many instances, a dog can discover the scent of his master out of hundreds, and even thousands, of confused scents. It is this wonderfully-developed sense which renders the dog so indispensable an assistant in the chase. Long before man sights the game the dog scents it. The track once discovered, he pursues it to the end. By the scent the deerhound follows the track of the bleeding game, the bloodhound that of a man. By means of the same sense the sheep-dog becomes aware of the approach of a beast of prey, and prepares for combat. The acuteness of the olfactory sense is closely connected with the length of the head; for the larger the skull, the larger are the nasal cavities, and the more numerous the endings of the olfactory nerves. Hunting-dogs have therefore usually long snouts (the greyhound, however, hunts more by sight), and in short-snouted dogs, like the poodle and bull-dog, the sense is less acute. By the scent, too, a dog will recognise its master often after years of separation, while in order to "retrieve" an object it

* The separate sections of what follows correspond with those of Section A. under "Wolf."

Digitized by Google

is necessary that it should have been allowed to smell it previously. It is this delicacy of smell, too, that makes strongly-smelling substances very repugnant to dogs, ammonia, eau de Cologne and similar substances, when held under its nose, arousing the greatest disgust.

3. The sense of *hearing* is developed almost to equal perfection, and on it depends the dog's employment as a watcher. Even when asleep—and he is never a sound sleeper—the dog hears the stealthy footsteps of an approaching thief. All watch-dogs proper (Pomeranians, sheep and house dogs) have erect ears, such being better adapted to catch sounds. Shrill sounds annoy dogs; many howl when they hear music or the ringing of bells.

4. Dogs used for the hunt, coursing, etc. (greyhounds and sporting dogs) are, like the wolf, fast *runners*, with slender, compressed bodies and long legs. The badger-hound, on the other hand, has to hunt beneath the earth. By means of his short, crooked legs and elongated, flexible body he can enter the holes of badgers and foxes, and move about in their underground passages. The claws of his toes, too, are strong, and consequently adapted for digging and burrowing underground.

5. In regard to *their teeth*, the largest dogs are not inferior to the wolf. They can break with ease even the firmest bones. Many, however, have entirely laid aside their carnivorous mode of life, and have become peaceful vegetable-eaters. Nevertheless a piece of meat is always a welcome gift.

6. The house-dog by training has lost much of its wildness. But several breeds (fox and stag hounds) still hunt in packs like wolves.

3. The Fox (*Canis vulpes*).

Poets and song-writers have glorified the fox above every other animal. Even the oldest legends speak of him as a cunning fellow, an accomplished rogue and a crafty thief. Both his bodily structure and intellectual characters adapt him perfectly to his vocation, in which he is excelled by no other animal.

1. The *colour of the skin* is a pale red, passing into gray. It is well adapted to the colour of the soil, and as well suited for a leafy wood as for a pine forest, for moor and field or rocky cliff. Cautiously creeping along, the fox escapes observation, being protected by the complete similarity of the colour of its skin to that of its environment.

2. *The senses are keen.* That of *smell* is as fine as in the dog. The *sight*, however, is sharper than that of his kindred. The vertical, oval pupils point it out as a nocturnal animal (see under Cat). Its plundering expeditions are not commenced until dusk, though, where it has nothing

Digitized by Google

to fear from dogs or men, it will even hunt by day. The presence of tactile hairs on the upper lip is in relation to this nocturnal mode of life, for on perfectly dark nights the sense of *touch* does duty for that of sight.

3. From its rather *short legs* and *slender, flexible body* it appears not to be so accomplished a runner as its cousin, the wolf, but rather given to creeping. Gliding along the ground noiselessly like a snake, it gets as close as it possibly can to its victim. At the same time its legs are sufficiently long and powerful to enable it to perform a fast and prolonged run. In this it is aided by the long bushy tail, which acts as an aerial rudder (see also squirrel); it is a master hand at "doubling." The long hind-limbs aid it in leaping. It is also an excellent swimmer, and able to wade through swamps and bogs. It can even climb up sloping trees. Thus its movements are manifold. As it does not chase its prey, but rather takes it by surprise, it never hunts in packs.

4. For the *teeth*, see Wolf, A. 5.

5. Conscious of its weakness in relation to men, dogs (and wolves), the fox is obliged to seek a safe hiding-place in holes and recesses underground. In making its home it uses its fore-limbs, which have strong claws, as shovels. It selects for its home a place between the roots of old trees. In order to be able to escape easily when danger threatens, it digs several passages to its resting-place. It is fond, too, of establishing itself in heaps of brushwood, abandoned badger-holes and similar places. Its hiding-places provide it with excellent shelter during great heat, heavy rains, storm or great cold. Here, too, the female brings forth her young—from four to seven in number—which she nurtures with great affection. In front of their hole they are carefully instructed in all the tricks of their future vocation.

6. Though many other beasts of prey far excel the fox in strength and other physical qualities, it can easily hold its own with any of them in *intellect* and sagacity. Observe with what caution it proceeds on its predatory excursions, making use of every possible cover to hide its presence. With what *slyness* and *cunning* it contrives to escape dogs and hunters. Even when hotly pursued it does not lose its *presence of mind*. *Patient* and motionless it remains when in ambush. If it feels sure of safety, it will boldly make its appearance in the poultry-yard even in broad daylight, and kill more than it can consume. It cleverly manages to avoid traps and snares.

7. The food of the fox consists chiefly of mice, as many as thirty or forty of these rodents having been found in the stomach of one of these animals. In the spring, however, when the number of mice falls short of satisfying its numerous progeny, it turns its attention to larger spoil.

Digitized by Google

Occasionally, too, when it has an opportunity, it seizes a young fawn, or a hare or partridge, plunders birds' nests, or captures a goose or two. It is also very fond of sweet fruits, especially grapes. Its usefulness in destroying mice, however, provided it does not become too numerous, far exceeds the damage it inflicts, and it should therefore enjoy the protection of the farmer. The sportsman, however, pursues it incessantly, and regards its winter fur as a small repayment for the many depredations it commits among the game.

Family 4: Martens (Mustelidæ).

1. The Pine Marten (*Mustela martes*).

(Length about 20 inches.)

The marten inhabits the whole of Europe and Western Asia, and is the *nimblest and cleverest of all predatory animals which lead an arboreal existence.*

1. The *fur* is thick, and consists of long brown bristles and short gray or yellowish woolly hairs. Its colour, as a whole, resembles that of the bark of the trees in which it lives and hunts its prey. Nor do the beautiful golden-yellow markings on the throat and neck betray its presence, as in creeping about after its prey it presses its body so close to the stems and branches that they cannot be distinguished. The thick warm fur, moreover, is an excellent protection against the coldness and dampness of the night.

2. The *senses* are acute. The broad ears point to an excellent hearing, and the tactile hairs on the upper lip are a sure indication of its stealthy murderous habits (see under Cat). The sight is sure even in the dark.

3. *Structure of Body.*—Compare with cat.

(*a*) The body is elongated and extremely flexible and pliant. There are no clavicles. These features are specially adapted to its method of locomotion, enabling it to creep with ease through the densest thicket and the most entangled branches. It can effect a passage through any opening through which it can just manage to force its head.

(*b*) The pliant, eel-like body and short, elastic legs further indicate its stealthiness. The under side of the toes being covered with hair, its walk is rendered inaudible even to the most sharp-eared animals.

(*c*) It is also an excellent *jumper*, clearing large distances as if by flight; the springy pliancy of the body and the great length of the hind-limbs render it an adept in this mode of progression, in which it is

Digitized by Google

further aided by the rudder-like action of the long bushy tail. Indeed, its fastest pace is made up of a succession of long leaps.

(*d*) It is an accomplished *climber;* by the aid of its supple body, short legs, and sharp claws, it is able to climb up even the smooth-barked trunks of beech-trees.

In short, the pine marten is a thorough athlete, a true arboreal creature, and an accomplished robber, scarcely inferior to the cat. It spends the day calmly reposing in a safe hiding-place, such as the deserted nest of a rook, dove, or squirrel. At the approach of night it wakes up for its murderous occupation. With lightning speed it runs up the trunks of the trees, up to their swaying tops, and climbs up and down among the branches; now, again, it may be seen creeping like a cat through the thick grass, inspecting every nook and cranny, sniffing at the holes in the tree-trunks, listening, peering now here, now there, in search of some sort of prey or other, be it a sleeping bird, a young hare, a mouse, or the like. Now it has caught sight of a squirrel. Unobserved it rapidly ascends the trunk of the tree on the other side of the creature, and mounts the branch on which it is sitting. Brushing the branch with its belly, it stealthily creeps up, cautiously placing one foot in front of the other; suddenly the squirrel catches sight of its pursuer, and now a mad chase begins. From branch to branch leaps the frightened creature, hotly pursued by the murderer. With one mighty leap it lands upon a neighbouring tree: the pursuer follows; up and down the trunk the race continues. It is only by taking a leap downward, which its pursuer cannot imitate, and rapidly gaining another tree, that the squirrel can hope to escape with its life. Otherwise it is doomed to succumb exhausted, and yield up its life under the teeth of the marauder.

4. The *dentition* of the marten is in fullest accord with its extraordinary rapacity. It exactly agrees with that of the cat (which see), except in the number of the premolars (three above, four below); but the projections of the separate teeth are even still more pointed. (With regard to breadth of jaws, strength of masticatory muscles, cranial crests, etc., compare the cat.) The mandible being capable of assuming a position almost at right angles to the upper jaw, the gape is of great width, and the marten is thus enabled to attack such animals as fawns or hares, and to carry off the eggs of large birds.

5. The *mental characteristics* of the marten are those of a true beast of prey: cunning, cautiousness, courage, ferocity, and cruelty. If it succeeds in entering a poultry-house or pigeon-loft, it will go on killing as long as anything living stirs within. It only drinks the blood of its victims, but with such greed that it almost seems to get intoxicated with it.

Digitized by Google

6. *Relation* of the marten *to other forest animals and to man.*

All animals which are its equals in size form its prey. It is, however, specially zealous in the pursuit of squirrels (which see), and by the destruction of these animals as well as the capture of mice the marten certainly helps in the preservation of the forest. However, by killing off the useful songsters of the woods and robbing their nests, by plundering all kinds of game, and by the great havoc it commits whenever it has an opportunity among the poultry, it does more harm than good. For this reason, and also on account of its valuable fur, which realizes as much as from eight to twelve shillings, it is an object of zealous pursuit on the part of the sportsman.

Related Species.

The **Stone or House Marten** (*M. foina*).—In this species the fur has more gray in it, and there is a white spot on the throat and chest. The stone marten prefers the neighbourhood of human dwellings for its habitat, and is found in stone heaps, barns, stables, and such-like places. It actively pursues poultry, and is specially fond of eggs.

The **Sable** (*M. zibellina*) is an inhabitant of the cold regions of Siberia. The animal is actively pursued on account of its valuable fur, which realizes as much as £25. In size it does not exceed the pine marten.

The **Polecat** (*Putorius fœtidus*) has dark chestnut-brown bristles and yellow, soft woolly hairs. Its usefulness in exterminating mice, marmots, and vipers certainly exceeds the damage it inflicts by its raids among the poultry. Like all the species of martens, this animal is provided with anal glands containing an evil-smelling liquid, which it employs as a most effective weapon against its assailants (dogs).

The **Ferret**, which is employed in rabbit-hunting, is an albino variety of this species. (The name "albino" is applied to all animal forms with white hair and red pupils.)

The **Weasel** (*P. vulgaris*).—The coat of this species, in correspondence with its habitat, is of a reddish-brown, earthy colour. Its elongated, snake-like body and small feet enable it to glide into the holes of mice and marmots. By exterminating these troublesome rodents it does good service to man.

The **Ermine** (*P. ermineus*).—This species in the autumn lays aside its earth-coloured coat and assumes a white winter fur. (Explain why.) Only the tip of the tail remains black. Ermine was once only worn by princes.

The **Mink** (*P. lutreola*), an inhabitant of Eastern Europe and Siberia, also furnishes a valuable fur.

Digitized by Google

2. The Badger (*Meles taxus*).

(Length about 2½ feet.)

A. Structure and Food.

From its plump body and strong legs, which in walking touch the ground with the entire sole of the foot (plantigrade), we may gather that we are dealing with a clumsy, awkward fellow, unable either to creep or leap or climb, or to run fast or slip through crevices. Consequently the badger is unable to prey upon quick-footed creatures, and has to be content with food of another kind; it is, in fact, an *omnivorous* animal like the pig and bear (which see).

THE BADGER. (One-eighth natural size.)

(*a*) The *teeth* give evidence of this fact. They resemble in general those of other carnivora, but the molars have broad crowns, and blunt tubercles; they are, therefore, more adapted for crushing than for tearing. The food of the badger consists of juicy roots, bulbs, fungi—also, when obtainable, all kinds of fruit, especially sweet grapes, the larvæ of the cockchafer and other insects, earthworms, snails, mice and rats, lizards, toads and snakes. Occasionally, also, it will plunder a bird's nest, or surprise a young hare in its hiding-place.

In the search for food it is aided by—

(*b*) Its long, broad and *sharp claws*, with which it digs for larvæ and worms.

(*c*) By its *trunk-like snout*, with which it burrows among the fallen leaves.

Digitized by Google

(*d*) The *neck* is short and muscular, enabling it to exert the utmost force in burrowing and rummaging. (Compare with mole.)

B. Structure and Habitat.

The badger cannot escape from its enemies (dogs and men) by the speed of its legs. Consequently it is a shy, timid creature, leading a nocturnal life, and lying hidden during the day in some safe hiding-place under the earth. It usually digs its burrow on the sunny side of wooded hills. Its dwelling consists of a central chamber and several tubular passages from 25 to 30 feet in length. The central chamber is warmly lined with moss and leaves, and serves as a sleeping apartment, living-room, and nursery. From it several passages lead vertically upwards for the purpose of ventilation. The whole structure displays exemplary neatness and cleanliness.

The structural characters of its body render the badger specially adapted for digging out a dwelling of the kind above described:

(*a*) The *legs* are short and very powerful.

(*b*) The sharp broad *claws* of the fore-feet serve as shovels, while by means of its hind-legs it energetically throws backwards the earth which has been dug up.

(*c*) In removing earth-heaps of larger size, it makes use of its sturdy body. Supporting itself on its *powerful feet*, it puts its back against the earth-heap, and by stepping backwards gradually pushes it out of its dwelling.

(*d*) The bristly hairs are short and lie flat on the skin, so that no dirt can accumulate between them. On the back they are of an earthy-gray colour, in correspondence with that of the animal's surroundings. Neither the black and white stripes on the head, nor the black colour of the feet and belly, render it conspicuous during its nightly excursions. Not being an adept at leaping, like the marten, its *tail* is but short.

C. Hibernation.

By the advent of autumn the badger has become well nourished and fat. This accumulated fat renders it capable of existing through its long winter fast. The layer of fat beneath the skin protects the body like a warm inner coat, the coarse-haired 'overcoat' not being well adapted to keep out the cold. Until the cold becomes severe it lives on the turnips and parsnips which it has stored up. Then it rolls itself up, in order to offer the least possible cooling surface to the air, and falls into a deep sleep. With the approach of milder weather it awakes, and goes to the nearest spring to drink; then once more returns to its castle, and continues its sleep till the actual return of spring.

Digitized by Google

D. Relations to Man.

Being an energetic destroyer of vermin, the badger should rather be protected than pursued. The skin, which is strong and durable, is used as a water-tight covering for trunks, etc. From the long, bristly hairs brushes of different kinds are manufactured. In some places also the flesh is eaten, and the fat melted down or used as fuel.

The badger is met with in the whole of Europe and Northern Asia.

3. The Otter (*Lutra vulgaris*).

(Length about 2 feet 6 inches.)

A. Structure of Body and Aquatic Mode of Life.

1. No warm-blooded animal can survive a continued exposure to severe cold (see p. 11). Water being a better conductor of heat than air, a considerable cooling of an animal body results if immersed in it for a prolonged time. The otter, however, is able to pass a large portion of its life in water, and even in winter pursues its prey in the water, though the surface may be covered with ice. Let us now examine by *what means the creature is protected against a loss of heat which would be destructive to its life.*

(*a*) The skin of the otter is always kept well greased, and thus never becomes really wet (compare with ducks and geese). This is effected by *special fat glands in the skin.*

(*b*) The fur is thick, and the bristles packed tightly upon the fur or under-hair. In this way small *air-spaces* are formed, which prevent the access of water to the skin. (This may be illustrated by dipping a bit of velvet in water and observing the result.) Air, however, is a bad conductor of heat.

2. Most land animals can progress for a short time in water by swimming. The otter, however, is much more of an aquatic than a land animal; it even pursues its prey by swimming or diving (see Section B.). *Its body, therefore, must be specially adapted for continued and rapid swimming and for diving.*

(*a*) The air-spaces between the hairs of the fur diminish the specific weight, air being specifically lighter than water.

(*b*) Friction is diminished, owing to the body being constantly kept well lubricated and slippery.

(*c*) The small, broad, flat *head*, the short, thick *neck*, and the slender, narrow body, form a wedge, as it were, which cuts through the water with ease. The body being of snake-like shape (hence the name

Digitized by Google

otter = German for adder) and very flexible, the animal is able to rapidly change its direction in the water, wherein it is further considerably aided by :

(*d*) The long, laterally compressed *tail*, which acts as a rudder.

(*e*) The short *legs*, the toes being provided with extensile swimming membranes, enable the animal to beat the water vigorously, and act, in fact, as oars.

(*f*) The cavity of the mouth is closed tightly against the entrance of water by muscular and elastic *lips*.

(*g*) The *nostrils* have the form of slits, and can also be closed.

(*h*) The *ears*, which can also be closed by a fold of skin, are hidden beneath the fur, and consequently do not impede motion.

B. Structure of Body and Mode of obtaining Food.

The food of the otter consists of frogs, crayfish, water-rats, and especially fish. Swimming birds also form its prey.

1. In the *pursuit* of these animals, for the most part themselves rapid and nimble in their movements, the otter is aided by—

(*a*) Its *speed*, in which it almost equals the pike and trout. It performs all kinds of antics in the water, as if at play—can rise and sink, turn sideways and backwards, with equal facility. Only at intervals does it place its nose above the water to take breath.

(*b*) The *sharpness of its senses*. It can see excellently under water. The long bristles on the upper lip in themselves indicate a fine sense of touch.

2. For *seizing and tearing* its prey the otter is aided by unusually sharp carnivorous teeth, from which no prey, however smooth and slippery, can escape.

C. A Despoiler of our Waters.

The otter is a terrible despoiler of our waters, devouring daily on an average about 5 pounds of fish (compute thence the annual amount). When it has thoroughly cleared out one piece of water, it passes on to another, and continues its work of destruction. In spite of its awkward and clumsy gait, it will, in order to gain its object, perform journeys of considerable length. Accordingly, all those who have the preservation of fish at heart are its sworn enemies. Its valuable fur by no means makes up for the depredations it commits.

D. Distribution and Habitat.

The otter occurs throughout the whole of Europe and Northern and Central Asia. It lives in a subterranean chamber, reached by a passage

Digitized by Google

about 6 feet in length, opening below the surface of the water. Another passage leading to the edge of the bank effects the ventilation of the chamber.

Family 5: Bears (Ursidæ).

1. The Brown Bear (*Ursus arctos*).

(Length about 6½ feet; height at shoulders up to about 4 feet.)

A. Structure and Mode of Life.

The bear is at once a *flesh* and *vegetable eater*. An examination of its anatomy will explain to us this double nature:

1. The body is stout.

2. It treads on the whole surface of its naked soles (plantigrade). It cannot accordingly run as fast as those carnivores which walk on their toes—Digitigrades (compare the wolf). Nor is it able to glide about or leap as nimbly as several of the latter. Still, its motions are not so slow as one might suppose, and it can easily outstrip a man in speed.

FORE-LEG OF BEAR.

O., Humerus; Sp., radius; E., ulna; Hw., carpal bones; M., metacarpals; 1, 2, 3, phalanges.

3. To some extent it makes up for its want of rapidity by the great mobility of its limbs and enormous corporal strength. Being able to walk on its hind-limbs, it can keep its fore-limbs free. It uses these like arms, and by embracing its victims, either men or cattle, breaks all their ribs. The hind-legs being much longer than the fore-legs, it can run more quickly uphill than downhill (compare with the hare). It can fell a man to the ground or break the backbone of a sheep or goat with one blow of its powerful paws, and when proceeding on its hind-limbs is even capable of carrying off an ox in its arms.

The bear is a skilful climber in virtue of its great strength, the mobility of its limbs, and the long, strong claws, which, however, are not retractile. It ascends with ease lofty trees and steep rocks. When in pursuit of cattle it first tries to frighten the beasts by setting up a terrible roar, and then drives them down into a ravine or chasm, which next it descends itself with great agility. It is also an excellent swimmer.

4. Though the ears are small, the *sense of hearing* is very fine, and the same may be said in regard to the *sense of smell*. It can hear the least

Digitized by Google

noise at a distance of as much as 200 paces, and can scent a person approaching it at the same distance.

5. Though not unadapted to a predatory existence, the bear is by no means so well equipped for this mode of life as, for instance, the cat or the marten. Consequently it is not limited *exclusively* to a flesh diet, as we may infer from a glance at its tremendous *jaws*. The canine teeth are, it is true, large, and form dangerous weapons. The premolars, on the other hand, are small, often drop out late in life, and are not, like those of cats, able to tear and mangle the food. Nor are the carnassial teeth as sharp and large as those of the latter species, but, like the molars behind them, have broad crowns and blunt tubercles, *being consequently more adapted for crushing up vegetable substances than for tearing flesh*. The molars are less like those of a cat than those of a pig. Indeed, like the latter, the bear is an omnivorous animal, which will eat anything that appeals to its palate. The incisors, accordingly, are much larger than in the true carnivora, and form good implements for biting

SKULL OF THE BROWN BEAR. (One-sixth natural size.)

off plants, grass and young corn, ears of cereals, berries, fungi, etc. It is also fond of fruit, ripe acorns and buckwheat; but its favourite delicacy is honey, which its ability as a climber enables it to steal from hollow trees. Occasionally it will even plunder a beehive. Besides this, it consumes all kinds of insects and their larvæ, worms and snails, and even digs up ant-heaps and devours their inhabitants.

6. Being chiefly a vegetable-eater, the bear is neither cruel nor bloodthirsty like the cat, the most typical of the carnivores. It neither shares "the cowardly bloodthirstiness of the wolf nor the sly cunning of the lynx." From man it invariably takes flight, but when driven into a corner may become a terrible enemy.

B. Hibernation.

In winter, when the chief source of its food-supply is cut off, the bear retires to a cave, a hollow tree-trunk or a swampy thicket on an

Digitized by Google

island, and indulges in a winter sleep, which is more or less prolonged, according to the duration of the cold season. Thus, in Livonia it lies buried under the snow for three or four months, whereas in milder districts the winter sleep lasts only a few weeks. If a thaw sets in, the bear leaves its resting-place for a short time in order to drink, and then retires to rest again. The thick fur during the long sleep serves as a protection against the cold. The masses of fat (from 100 to 200 pounds in weight) which it has stored up in its body during the period when food was superabundant are now used up in sustaining the function of the internal organs (see bat). By the time the snows have melted it wakes up quite emaciated. Plant life, however, in early spring is not sufficiently plentiful to supply the necessary quantity of food; hence at this season more especially the bear is compelled to go in pursuit of animal prey.

C. Distribution.

The bear is met with in various parts of Europe, and in Asia north of the Himalayas. In our continent it is at present only found in high mountain ranges (the Alps, Pyrenees, Carpathians and the Balkans), and the dense, swampy forests of Russia. In the animal lore of Germany it goes by the name of Bruin, and is regarded as the king of the animal world. But it has now been extinct in Germany for many years. On account of the depredations it commits among game and cattle, it is everywhere keenly pursued. It is also much valued on account of its thick, shaggy fur, which in *colour* closely matches the soil. The flesh, though not particularly palatable, is eaten in various places. But smoked bear's feet and bear hams are regarded as delicacies.

2. The Polar Bear (*Ursus maritimus*).

This species excels the brown bear in size, strength and weight (in length it reaches about 8 feet, and in weight 1,600 pounds). It inhabits the coasts and islands of the Arctic Ocean.

1. It is protected against the *fierce winter cold* of its inhospitable home by—

(*a*) A *thick shaggy fur*, between the hairs of which are large air-spaces (air being a bad conductor of heat).

(*b*) A thick *layer of fat* beneath the skin, fat also being a bad conductor of heat (see under Seal).

2. In the *pursuit of its prey* on shore it is aided by—

(*a*) The *colour* of its fur, which cannot be distinguished from that of the snow. (It creeps towards its prey and takes it by surprise.)

(*b*) The *hairy covering of the soles* of the feet, in virtue of which it can move with ease over even the most slippery ice. (In Germany and other

Digitized by Google

parts of the Continent people wear felt pads under the heels of their boots to prevent themselves from slipping on frozen roads.)

Its prey consists of the few mammals which are found in its home, and which are also provided with a white fur. Being a skilful climber, it can ascend the so-called "bird-cliffs," where it consumes hundreds of eggs and young nestlings. Like its relative, the brown bear, it, too, does not despise vegetable food (grass, berries, lichens and mosses) which, during the short summer of the Arctic North, grows upon the thawed surface layers of the soil.

3. The land, however, cannot supply this gigantic animal with sufficient food, especially during the long winter of these regions, and it is therefore compelled to make *the sea its principal hunting-ground.*

(*a*) Its body is protected from the *fatal effects of cooling* in the icy water by the *large air-spaces* between the hairs of its fur, by the thick *adipose layer* under the skin already mentioned, and by the copious *secretion of fat from the glands of the skin*, by means of which the furry coat is kept constantly lubricated, and thus never allowed to get wet (compare the duck).

(*b*) It is as much at home in the water as on land, *swimming* being facilitated by the large *air-spaces* between the hairs of the shaggy coat and the *fat accumulations* within the body; for air as well as fat, being lighter than water, help to diminish the specific weight of its body. Moreover its gigantic strength, wide paws and the cutaneous webs between the toes, enable it to swim with both rapidity and endurance. Seals, walruses, etc., lying on the ice near their air-holes it approaches by noiselessly diving, swimming cautiously up to them beneath the ice, and then suddenly rising out of the water in front of them. It is also an adept at catching fish.

4. The supply of animal food being always abundant, the Polar bear is not obliged to have recourse to a winter sleep.

ORDER IV.: FIN-FOOTED CARNIVORES, OR SEALS (PINNIPEDIA).

CARNIVOROUS animals, leading an aquatic life, with spindle-shaped body and finlike fore and hind limbs.

The Seal (*Phoca vitulina*).

(Length 5½ to 6½ feet.)

A. Distribution and Habitat.

The seal is found on the coasts of the Northern Atlantic, both on the European and American side. It is common in the North Sea and the

Digitized by Google

Baltic. Its real home is the sea, and it only leaves the water for the shore in order to sleep or bask in the sun. Large companies of seals may be seen under these conditions on the sands or the cliffs by the shore, or on floating ice-floes. Here, too, may be heard their hoarse barking, resembling somewhat that of the dog (whence the German name of this animal, *see-hund* = sea-dog).

The seal accordingly combines the habits of a land and water animal, and its structure and anatomy also correspond with this double nature.

B. The Seal regarded as an Aquatic Animal.

i. Protection against Loss of Heat.

As the seal passes two-thirds of its life in the water, no fur, however thick or dense, would be able to maintain the heat of its body (as, for instance, in the case of the otter); for after a day

SEAL. (One-twenty-fourth natural size.)

passed in the water, so much air would gradually escape from the fur that the water would penetrate to the skin, and produce a great cooling of the body. Accordingly other means are provided for preventing an excessive loss of heat, in the shape of a *thick layer of fat* or *blubber* which envelops the whole body.

ii. The Seal as a Diver and Swimmer.

The sea supplies this animal with an abundance of food, chiefly consisting of fish and the larger kinds of crustacea. In winter, when wide stretches of the surface are frozen, it keeps holes open in the ice by repeatedly diving in and out. The seal is a *rapid swimmer* and *skilful diver*, these capacities being essential to it both in the pursuit of the fishes and crustaceans which form its prey, and also to enable it to escape from its chief enemies, the greedy shark and the rapacious dolphin (which see). In swimming it moves through the water with the

Digitized by Google

speed of a shark, and with equal ease on its back or belly or side. Indeed it performs all kinds of gambols in the water, diving down into the depths with the speed of an arrow, and again shooting up to the surface with equal rapidity. It is able to remain seven minutes under the water without breathing.

Differing thus in the manner of its life from most other mammals, we may expect to meet with special arrangements in the structure of its body.

1. The head passes straight into the short thick neck, and this again is continuous with the cylindrical elongated trunk, the whole body thus acquiring the form of a *spindle*, which cuts through the water with ease. (Compare with fishes.)

2. In consequence of the strength and thickness of the neck, the head must follow the direction in which the trunk is moving; were the neck short and thin, it would be deflected —by the resistance of the water—from the direction of motion, and consequently impede progress.

SKULL OF SEAL. (Two-sevenths natural size.)

3. The *fore* and *hind limbs* form the oars and rudder of the boat-shaped body.

(*a*) The *feet*, the toes of which are connected by webs, form broad *finlike* plates. In their backward movement the toes are spread out; in the forward movement they are laid together, so as to offer the least possible resistance to the water. (Compare the duck.)

(*b*) Both the upper and lower segments of the limbs are *much shortened*, and, for the most part, *hidden within the body*. Thus, only the finlike hands and feet project into the water, so that their strokes are short and quick.

The shoulder-blade, and the upper and lower bones of the limbs are very *broad*, and thus, in spite of their shortness, offer the necessary surface of attachment to the muscles. (Compare the mole.)

(*c*) The limbs are not, as in animals which progress by walking, directed downwards. The *hands* (as in the mole, which, as it were, swims in the earth) are directed *obliquely outwards*, and the *feet*, between which the remnant of a tail is visible, are directed *posteriorly*, their inner surfaces being turned towards the middle line of the body. By powerfully striking its feet together, the animal pushes away the water between them, and propels its body forwards. The feet, in this action, are assisted by the hands, which at the same time are used for steering. (Illustrate this method of steering by means of a small boat which is steered by means of the oars only.)

Digitized by Google

4. The specific weight is diminished by the *thick subcutaneous layer of blubber* (fat being lighter than water), and also by the *extreme lightness of the bones of the skeleton* (some of the cranial bones are almost as thin as paper).

5. The *smoothness of the skin* has the effect of diminishing friction in the water.

6. *External ears* are absent. These, if present, would impede the animal's progress. Their absence does not affect the sense of hearing, inasmuch as the animal spends the greater part of its life in the water, which is a better conductor of sound than air, while the vibrations of sound are conveyed to the internal ear through the whole body. (Compare the mole.) The opening of the external ear passage is closed while the animal is diving below the water.

7. The cleft-like *nasal apertures* can also be closed at the will of the animal.

iii. All the Food of the Seal is supplied by the Sea.

1. In the pursuit of its prey it is aided by—

(*a*) The *rapidity* and *agility* with which it swims, and its power and endurance in diving below the surface.

(*b*) Its *sharp-sightedness* and a *fine sense of touch* in the tactile hairs on the upper lip. (Inquire why these two senses must be specially considered in the case of an aquatic animal.) The presence of so large a number of these bristles upon the divided upper lip becomes explicable when we reflect that during the night, its principal time for hunting, and also in the dark depths of the sea, the sense of touch is the only one on which the creature can rely.

2. As the seal, for the most part, feeds upon animals of rather large size, its *teeth* are of the same type as those of other carnivores; but inasmuch as it swallows its prey whole, they do not exhibit the same diversity of form and size as, for instance, those of the cat (which see). They are, on the contrary, of almost equal size. The molars and premolars are provided with very sharp points. The teeth are thus excellently adapted to seizing and maintaining hold of the smooth and slippery fish which chiefly form its prey. The mandible is firmly articulated as in the other carnivora.

C. The Seal as a Land Animal.

We have seen that the seal is pre-eminently a denizen of the waters. Consequently its body is adapted in a high degree to an aquatic life. Still, as about a third part of its life is also passed on dry land, arrangements must be provided which render such an existence possible.

Digitized by Google

1. Its movements on land (or ice) are extremely awkward and ungainly. Its limbs being so short, and placed in reference to the body in the manner described above, the animal cannot progress by walking; it can use its fore-limbs only for holding on when ascending a cliff. The seal, in fact, progresses more after the manner of the looper caterpillars; supporting itself on its breast, it bends up its back so that the hinder part of the abdomen is brought close to the chest; it then rapidly stretches its body, whereby the fore-part of the body is thrown some distance forwards. The thick layer of blubber has the effect of lessening the shocks caused by these movements.

2. For hours, and even days, the seals, especially while suckling their young, which are brought forth on the land, rest on the damp soil or the storm-tossed cliffs or ice-floes without suffering from the cold. The thick *layer of fat*, and, in a secondary degree, the *thick fur*, prevent any loss of heat so perfectly that not even a trace of ice is seen to have thawed underneath an animal which has been lying for hours on an ice-floe; also, as in the case of the otter, the hairs of the fur are always so well lubricated as not to be wetted by the water.

3. In consequence of the awkwardness of its movements, the seal on dry land is somewhat helpless against its *enemies* (Polar bears, man); but by the help of—

(*a*) Its *sharp senses* it can descry an enemy even at a distance, and at once makes for the protection of the sea. The sense of smell is probably even keener than the sight and hearing, the nasal cavities being as large as in the dog (which see).

(*b*) The *colour of the skin* also affords some protection to the animal when resting on the shore, its back being yellowish-gray, and dotted with brown or black spots, thus bearing more or less resemblance to the colour of the ground.

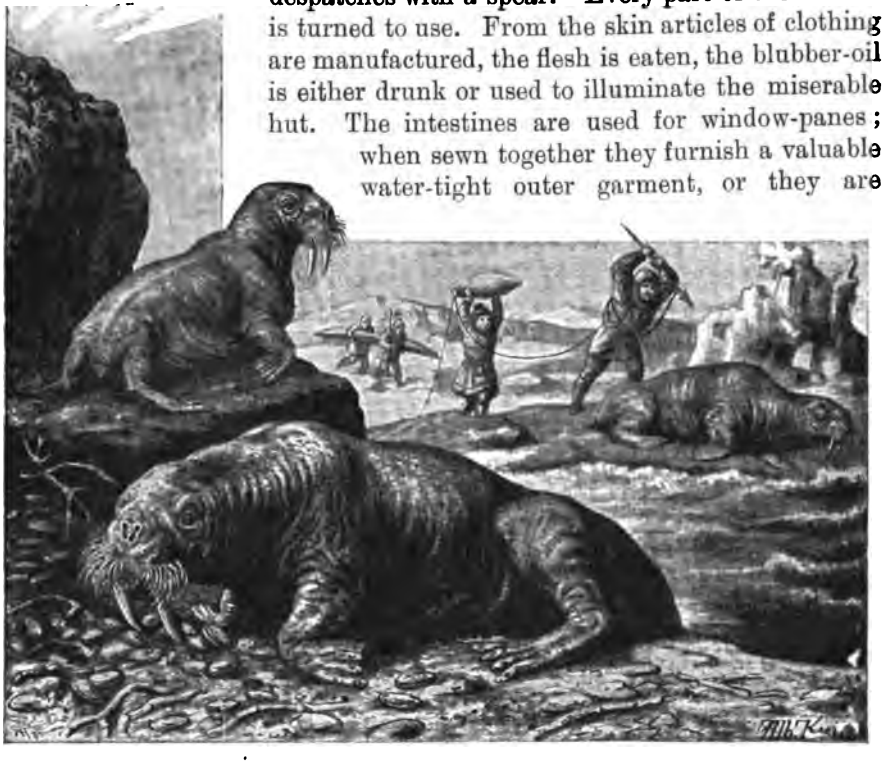
D. Importance of the Seal to Man.

The seal, being a destroyer of an immense number of food-fishes, is undoubtedly the most destructive animal of our coasts, and consequently incessantly persecuted by fishermen. Neither the skin nor the blubber, from which train-oil is made, make up for the damage it inflicts. To the Greenlander, on the other hand, the seal and its nearest kindred are uncommonly useful; indeed, were it not for the presence of these animals in the icy waters which wash the coasts of Greenland, these regions would cease to be habitable.

In his light, one-seated canoe (kajak) the hardy Greenlander rows out to sea, making his way through icebergs and floes, and endeavours, with as little noise as possible, to approach the seal or to surprise it

Digitized by Google

when rising to the surface. Approaching as near as possible, he hurls his harpoon into the animal's body, the weapon being provided with barbed hooks and attached to a long coil of rope (see the illustration of the walrus). With lightning speed the wounded animal dives down into the depths. An air-bladder attached to the end of the uncoiled line indicates to the hunter the position of his game, which he finally despatches with a spear. Every part of the animal is turned to use. From the skin articles of clothing are manufactured, the flesh is eaten, the blubber-oil is either drunk or used to illuminate the miserable hut. The intestines are used for window-panes; when sewn together they furnish a valuable water-tight outer garment, or they are



WALRUSES AT EBB-TIDE.
(The recumbent animal in the foreground about one-seventieth natural size.)*

twisted into ropes and thread. The blood, mixed with sea-water, forms a nutritious soup. All kinds of household articles are made out of the large bones, while the small ones serve as toys for the children.

Related Species.

Of the numerous members of the seal family, we shall only briefly describe the **Walrus** (*Trichechus rosmarus*), which inhabits the circumpolar

* The second Eskimo carries the air-bladder of the harpoon-line.

Digitized by Google

seas. This powerful animal reaches a length of from 17 to 19 feet, and may weigh as much as 3,000 pounds. Its limbs are longer than those of the seal, and the hind-limbs can be bent round towards the belly. The animal, accordingly, can walk, though awkwardly, after the fashion of land animals. Its food consists principally of shell-fish, which it either tears off from the rocks by means of its two powerful projecting tusks (*i.e.*, the two upper canines) or rakes up from the sea-bottom, using its tusks as a kind of two-pronged rake. The upper lip is covered with horny bristles of about the thickness of a quill. These act as a kind of sieve for separating the shell-fish from the mud in which they are embedded. Their hard shells it crushes with its broad-crowned molars (compare with the duckbill).

The walrus frequently attacks man, even when not provoked, and great caution is necessary lest this ocean giant, with one blow of his powerful tusks, shatter the side of a boat. It will even defend itself on land, unlike most other members of this family, which generally allow themselves to be driven far inland to the killing-places, where they are despatched with ease by a blow on the nose with a club. Formerly the walrus was killed only for the sake of its tusks, which furnish a good kind of ivory, but nowadays the skin and blubber of this, as of the other species of the seal family, are also turned to account.

ORDER V.: BATS (CHIROPTERA).

A FLYING membrane extends between the long fore-limbs and the short hind-limbs. The dentition consists of all three kinds of teeth. Insect or fruit eating animals (insectivorous or frugivorous). Nocturnal or crepuscular in their habits.

The Long-Eared Bat (*Plecotus auritus*).

(Body and tail each about $1\frac{3}{4}$ inches long; width from tip to tip of extended flying membrane about 10 inches.)

This animal derives its name from the conspicuously large external ears.

Bats pass a great portion of their lives traversing the air in search of food (see Section B.). They thus have to bear the whole weight of their body (compare with land and water animals), and often even their young, which hang on to the breast of the mother until they are able to go in search of their own food. Their mode of locomotion, then, is quite different from that of all other mammals, and we need therefore feel no surprise that their body is constructed in many ways quite differently.

Digitized by Google

Their structure appears, accordingly, strange and peculiar, but on closer examination will be found perfectly adapted to their mode of life and habits.

A. Structure of Body and Methods of Locomotion.

i. How Motion through the Air is effected.

1. *The Bat possesses an Apparatus for Flight.*—(*a*) A flying membrane extends on each side between the body, the fore and hind limbs, and the tail, which equals the body in length. When this is unfolded, the animal rests in the air upon a very large surface. It is not as yet, however, carried by the air. This is effected by the constant downward movements of the fore-limbs, each depression of these limbs bringing in its train a condensation of the atmosphere. The larger the flying membrane, the more easily will the animal be able to support itself in the air, and the more rapidly will it be able to progress. Hence the strikingly *large size* of the flying membrane. (What kind of bats are probably the fastest and nimblest in progressing through the air? Compare with swallow and common fowl.)

(*b*) With the greater breadth of the anterior portion of the flying membrane is correlated a great elongation of the *bones of the arm*. The metacarpal bones and fingers are likewise elongated, and, after the manner of the ribs of an umbrella, keep stretched that part of the membrane which projects beyond the lower arm. The thumbs and feet, not being included within the membrane, are not increased in length. From the heel backwards extends a bony process, the *spur*, not found in any other mammal. It supports the portion of the flying membrane between the legs and the tail.

(*c*) In the act of fluttering the bat alternately spreads out and folds together its flying membrane. (When is it spread? when folded? what is the object of these movements? Compare with seal.) The membrane, accordingly, is highly *elastic*, and in order to maintain it in this condition it is carefully *lubricated* every time the animal sets out on one of its flying excursions, the fat used for this purpose being secreted by special glands situated between the nose and eyes.

(*d*) *Clavicles* are present, and give firm support to the arms, on which the principal work falls during the animal's progress through the air (see p. 11).

In the true ribs the lower portion, which in most other mammals remains cartilaginous, is completely ossified, whilst the different sections of the sternum coalesce into one single piece. In this manner the *walls of the thoracic chamber acquire great firmness*.

(*e*) For the performance of much work *strong muscles* are required,

Digitized by Google

and thus we find in the bat very powerful thoracic muscles, which are attached to remarkably large *shoulder-blades* and to a *high bony crest* developed along the median line of the sternum, which thus presents arrangements very similar to those which obtain in birds.

2. *How Flight is facilitated.*—The bones of the bat are not hollow (pneumatic) like those of birds, nor do we meet with air-sacs within the body cavity, as in the latter (which see), so that a diminution of the weight of the body is brought about by other means.

(*a*) All the bones (excepting the shoulder-blades and clavicles) are extremely *thin*, but at the same time rigid.

(*b*) The *supporting surface* is much larger than in birds. In the latter

THE LONG-EARED BAT, WITH SKELETON MARKED IN. (Natural size.)
1, Thumb; 2, 3, 4, 5, remaining digits; C. (M.), carpal bones; Sp., spur; E.C. (Od.), ear-covers.

this surface is formed by the wings only and their feathers, whereas in the bat it extends beyond the legs to the tail.

(*c*) The size of the creature is small, the intestine short (see Section B, 6 and 8).

Nevertheless, progress through the air is a less easy task for the bat than for the bird, with its specifically lighter body. Thus, the bat is not able to soar in the air like a bird of prey (which see). To prevent itself from falling, it must constantly keep its flying membrane in motion. As in the case of other mammals, excessively strong movements of the fore-limbs produce "loss or shortness of breath"; consequently the flight of bats is not as enduring as that of birds (see the section on the Respiration of Birds). Bats can, however, move through the air with consider-

Digitized by Google

able nimbleness, and by help of the tail, which acts as a rudder, can even execute rapid turns.

ii. How Bats creep and climb.

The bat, however, cannot be said to be an aerial creature in the same degree that the fish is spoken of as an aquatic animal. In order to rest it is obliged to descend upon solid objects. The limbs, accordingly, are not merely instruments for flying, but also for *creeping* and *climbing* (compare with seal).

1. By means of its claw-shaped thumb, it hooks itself on to the ground, and then pushes its body forward with its feet. (Would this be possible if thumb and feet were included in the flying membrane?) In this manner the bat creeps, though somewhat awkwardly.

Long-Eared Bat in Suspended Position. (Natural size.)

2. On account of the shortness and weakness of its legs, the bat cannot dart upwards into the air in the manner of a bird, nor is it able to unfold the flying membrane to its fullest extent while still on the ground, since the legs are to some extent enclosed within it. For this reason it climbs up tree-trunks, walls, or other objects, by the help of its claw-like thumb and its feet, and then, by allowing itself to drop, is once more enabled to launch itself into the air.

3. For the same reason the bat assumes a peculiar position even when at rest, suspending itself by the feet, head downwards, from projecting beams or edges of its dwelling-place. If while in this position it allows itself to drop, it can at once expand its flying membrane. In spite of their extreme slenderness, the feet are yet able to maintain the animal in this suspended position during the day and the period of hibernation (see below).

B. Structure of Body and Food.

The bat passes the day asleep, only making its appearance at sunset for the nightly pursuit of its prey. This latter consists of flies, gnats, beetles, and more especially moths. The bat, accordingly, is a *nocturnal insectivorous* creature, and its structure is admirably adapted to these habits.

Digitized by Google

1. As may be gathered from their small size, the *eyes* of the bat are not sharp-sighted. (Compare, on the other hand, the eyes of the owl.)

2. The *sense of touch*, on the other hand, is developed to a degree almost inconceivable to human beings. Thus, bats whose eyes had been covered with sticking-plaster, and who were then let loose in a room in which a large number of threads were extended, never once collided with the latter. This can only be explained by assuming that the animals are sensible to the vibrations of the air generated by the stroke of their flying membranes and reflected by surrounding objects. The fineness of the threads in the above experiment itself shows how faint such vibrations must be. *In the same way the animal becomes sensible of the faint air vibrations generated by a flying insect. It feels its prey, as it were, from afar.* This extremely fine sense of touch has its seat in the flying membrane, in the delicate pinnæ of the ears, and the

SKULL OF A BAT. (Magnified five times.)

covers placed in front of the external auditory aperture. The existence of this sense also renders intelligible the unusual size of the external ears and the absence of the thick coating of fur from them as well as from the flying membrane.

3. The *sense of hearing* is equally acute, as is, indeed, shown by the voice of the animal, which is so fine and high-pitched that many people are unable to perceive it at all. The creature, on the other hand, must be able to hear tones of this kind. (Why?) The large pinnæ, which are movable and capable of being laid back, in fact, represent ear-trumpets. At the commencement of the aerial voyage they are erected, and probably enable the animal to hear sounds inaudible to human ears, such as the flight of a moth, more especially as the animal itself moves without sound. (Compare with cat and owl.) Animals endowed with a fine sense of hearing cannot tolerate loud tones or noises. (Compare the dog.) Hence, according to some naturalists, the ear-covers of the bat, by closing the auditory passage, save the animal from being annoyed or tormented by sounds or noises of this description.

Digitized by Google

4. The bat catches its prey while flying, consequently the *mouth is widely cleft.* (Compare the swallow.)

5. The *teeth* have the appearance of rows of needle-points. The molars have pointed cusps. They, as well as the long dagger-shaped canines, are able to bore with ease through the hard wing-covers and the armour of larger insects, from which blunt teeth would glide off. The animal uses its teeth neither for gnawing nor grinding (like a herbivorous animal), but merely for biting and boring. Since the points of the teeth of one set are received in the interstices of the other set, the crowns are not worn down by use. (Compare with cat.)

6. The animal diet corresponds to the short intestine, only three times as long as the body.

7. The *neck* is very short. A long neck, by which the head is enabled to move in all directions (compare the stork), would be useless to a bat, which in the pursuit of prey during flight can easily turn head and body together in any direction it pleases (compare the swallow).

8. With the nature of the food is also correlated the small size of the animal. A large animal could not obtain enough insects to satisfy itself.

C. Hibernation of Bat.

It would be difficult, if not impossible, for a bat to exist through the winter, unless it adopted the habit of hibernating; for it cannot pursue in their hiding-places those insects which live through the winter, nor is it able to lay up a store of provisions for that season like the squirrel (why not?), nor are its powers of flight of so enduring a nature as to enable it like birds to migrate to warmer countries. Accordingly, when the raw weather sets in, the bat seeks out as protected a hiding-place as possible, though one not too dry (why?), such as a mountain cave, a cellar, a loft, a ruined building, the hollow trunk of a tree, and so on. There these animals may be met with often in crowds, hanging up by their feet, unconscious, stiff and motionless. In this condition the heat of the body drops from 35° C. to 14° C. (95° F. to 57° F.); the pulse only beats about once every three minutes, and the respirations are rare and hardly perceptible. But as soon as Nature reassumes her garment of green and the thousands of different kinds of insects reappear, the bat, too, reawakens to a new life. Let us now inquire how it has been able to tide over the long period of cold and fasting.

1. If the body-heat of an animal, especially a warm-blooded one, sinks below a certain minimum, the creature must perish. In the case of the bat this issue is prevented by several means:

(*a*) *An Uncommonly Thick Hairy Covering.*—The number of hairs covering the tiny body has been computed at about 1½ millions. These

Digitized by Google

hairs, moreover, display a quite peculiar structure, not consisting, as in most other animals, of tubes of equal thickness, but, like the stalks of certain grasses, of conical and funnel-shaped segments. On account of the roughness of their surface, these hairs cling to each other more tightly than smooth ones, so that parts of the body are not so easily laid bare by a draught of air.

HAIR OF LONG-EARED BAT. (Magnified 240 times).

(*b*) The *flying membrane*, which enfolds the body like a mantle, likewise forms a protection against an excessive loss of body-heat, since the air enclosed within it acts as a bad conductor of heat.

2. Although during its winter sleep the bat is suspended like a corpse, life is by no means extinct in the interior of its body. The lungs, the heart and the other organs continue their work slowly but uninterruptedly. Now, even the least amount of work can in the animal body only be performed by the combustion of food material (see p. 6). Consequently the bat, from the superabundance of its food during the mild seasons, stores up, as in a larder, a supply of such material in its body, more especially in the form of *fat*. This fat by degrees enters the circulation, and is conducted thence to all the organs in which it undergoes combustion. In this manner the needful quantities of heat and force are continually produced afresh, so that, though the animal machine works slowly, it is not brought to a standstill. (What would happen if the animal, during its winter sleep, breathed as deeply and as often as during the period of its greatest vital activity?)

3. The *distribution* of bats is rendered explicable from their mode of life. The closer we approach the pole, the greater becomes the diminution in insect life. In cold countries the animals, even during the warmer months, would scarcely be able to find sufficient food, much less be in a position of laying up a store within their body for the winter. During cold and long winters they would in such countries inevitably perish from loss of heat or want of food—would, in fact, either freeze or starve. Accordingly we do not meet with bats beyond the sixtieth degree of north latitude; but their true home is in the warm South, with its abounding insect life.

D. The Bat in its Relations to Man, and its Importance in the Economy of Nature.

1. In popular superstition bats, from their noiseless flight and their nocturnal mode of life, were once considered as evil spirits, and still at

Digitized by Google

the present day it is the fashion to equip dragons and devils with bats' wings. Ignorant people, again, charge them with eating up the bacon in the larder; but the structure of their teeth alone suffices to disprove this charge. (Who is probably the guilty party?) Equally absurd is the belief that they entwine themselves in the hair of people.

2. Bats, like other flying or fluttering creatures, progress with much greater difficulty than animals which move on the ground. (Why?) In proportion as an animal moves with greater difficulty, it requires to exert greater force to execute its movements, and the more force an animal expends, the larger the quantity of food it must take in order to replace lost energy. Bats, accordingly, are *extremely voracious creatures.* Thus, in one instance a bat is known to have consumed twelve specimens of the noxious cockchafer at one meal; and as bats prefer to fly in the dark, and live mostly on moths, the larvæ of which devastate our fruit and forest trees, we must consider them as *animals of extraordinary utility to man, which he should endeavour as much as possible to preserve.* They, in fact, continue during the night the work performed by the song birds during the day, and are an excellent "night police," so to speak, as we may learn from the following instance: At the beginning of this century a large number of oak-trees were cut down in the neighbourhood of Hanau (Germany), in the hollow trunks and branches of which thousands of bats were found in the hibernating condition. In sawing and splitting up these trees many of the animals perished from the cold, many were killed wantonly. The result was a marked and rapid increase in the larvæ of the Processional moth, which latter had been hitherto for the most part destroyed by the bats. From that time onwards these insect pests increased to such a degree that in the course of the following years first all the oaks, and afterwards also many other trees, for miles around were exterminated.

3. *Its Enemies.*—The owl pursues the bat during its flight; the marten, the polecat, the weasel, and the cat while it is at rest. It, however, manages to protect itself against these marauders by choosing for its refuge places difficult of access, such as cornices, small projections on vertical walls, etc. Its gray *colour* also is a protection (protective colouring). A sleeping bat may almost be mistaken for a dusty spider's web.

Related Species.

1. **Insectivorous Bats.**—A large number of bat species are found in Britain and the neighbouring continent. All of these in their structure and mode of life much resemble the long-eared bat. Only *two* species, the **Large** and **Small Horseshoe Bat** (*Rhinolophus ferrum-equinum* and *Rhino-*

Digitized by Google

lophus hippocrepis) require brief consideration. These carry on the nose peculiar membranous appendages by which the acuteness of the sense of touch is probably further increased. They are consequently described as **Leaf-Nosed Bats**, in contrast to the **Smooth-Nosed** species, which, like the long-eared bat, do not possess these leafy appendages. Both are insectivorous, though in exceptional cases they may suck the blood of other bats or of sleeping game. The much dreaded **Vampire** of South America (*Vampyrus spectrum*), of which so many gruesome stories are told, is also principally an insect-eater, and only attacks birds and mammals for the purpose of sucking their blood when there is a dearth of insect food.

HEAD OF THE LARGE HORSESHOE BAT. (Twice natural size.)

2. The **Fruit-eating (Frugivorous) Bats** inhabit exclusively the warmer countries of the Old World. (Why?) The best-known species is the **Flying Fox** or **Kalong** (*Pteropus edulis*), an animal about 16 inches long. It is found in the East Indian Islands. Living exclusively on fruit, its molar teeth have blunt tubercles. It does not hibernate. (Why?)

ORDER VI.: INSECT-EATERS (INSECTIVORA).

SMALL plantigrade animals with five toes provided with strong claws. In the dentition all three types of teeth are represented. The molars have pointed prominences. The nose is prolonged into a proboscis.

Family 1: Moles (Talpina).

The Mole (*Talpa europæa*).

(Length about 6 inches.)

As the bat is adapted to a life in the air, and the whale to an exclusively aquatic existence, so the body of the mole is more especially constructed for *life in the earth.**

A. Adaptation of the Body for a Subterranean Existence.

1. The *fore-limbs* act as shovels by the help of which the animal digs (or, rather, scrapes) its underground passages, at the same time throwing

* The German name for the mole, viz., *maulwurf*, signifies "a thrower up of *mull*," *i.e.*, mould.

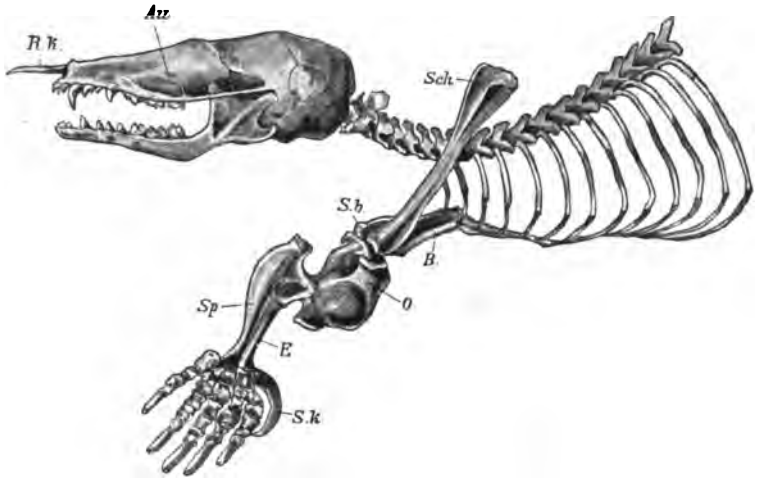
Digitized by Google

the loose earth behind it. The structure of these limbs is accordingly quite different to that of the hind-limbs, which are much weaker, and in which the whole sole of the foot is used for walking.

(*a*) The fore-limbs do not, as in most other mammals, point downwards, but away from the body *laterally* and *horizontally*.

(*b*) The hands are very broad, and their *inner surfaces*, which are hairless, are *directed posteriorly*. Their breadth is still further increased by a sickle-shaped bone placed on the outside of each of the thumbs, the so-called "falciform bone." The short *toes* are for the greater part of their length united by webs. They have long broad nails sharpened at the points.

(*c*) The mole scratches or scrapes loose the earth with its feet in the



ANTERIOR HALF OF THE SKELETON OF THE MOLE.
(One and a half times natural size.)

R.k., Nasal cartilage; Au., eye socket; Sch., shoulder-blade; S.b., clavicle (lateral view); O., humerus; Sp., ulna; E., radius; S.k., "scraper"; B., sternum.

same way as we should scrape off a portion from some solid object with a spoon. In the latter operation, it is most advantageous to hold the handle of the spoon as short as possible (why?), and accordingly in the case of the animal the hand has a very short stalk; *i.e.*, the upper and lower arms are very short and quite hidden within the body, the hand only projecting out of the fur. The bones of the arm are of extraordinary strength, and impart great firmness to the stalk of the hand.

(*d*) The clavicles are strong, and afford firm points of attachment to the fore-limbs. (Compare with the bat and bird.)

2. In loose and especially sandy soil the *head* assists in forcing a

Digitized by Google

passage for the body. Being wedge-shaped, it can by powerful forward pushes be easily driven through the soil. This wedge-shaped form of the head is due to the elongation of the nose into a *snout* or *proboscis*. Though rendered firm by the presence of cartilage, this proboscis—as can be easily proved in the living or dead animal—nevertheless remains pliant and movable. It follows accordingly *that the head cannot be used as a boring instrument in a hard or still less a stony soil.* Here the digging feet alone can operate. These, however, do not extend beyond the front of the snout in the extended animal, as it is indispensable that they should for carrying out their work. Accordingly, to enable the hands to precede the head in hard soil, the *head is drawn very far back*, further, in fact, than is possible in the case of any other mammal. (This can be very clearly shown in a dead animal by pressing the head.)

Further, the head also acts as a *shovel.* Having previously made a passage opening on the surface, the animal, by powerful pushes of the head, throws up from its underground tunnel any loose earth which has accumulated there. This explains the origin of a *molehill.* While thus occupied the cautious creature, however, always takes care to keep its body covered with a layer of loose earth from 6 to 8 inches in depth.

3. The *hind-limbs* take no part in the work of burrowing. They are, therefore, much weaker than the fore-legs, and have the usual form. Treading with the whole sole of the foot for the sake of friction, they push—

4. The *cylindrical body* forwards. This shape is of great importance to a burrowing animal, for the size of the burrow depends on the greatest thickness at any part of the body. And if the body were flattened either laterally or horizontally it could not turn round on its axis. (What is the shape of other burrowing animals known to you?)

5. The neck is so short as to be quite imperceptible from outside. The result is a considerable saving of force, for a long neck, by being deflected when the head is thrust forward, would involve a considerable waste of force.

6. When we consider how the mole alone and unaided forces his way through the solid earth, which man can only loosen by the aid of sharp iron implements, and how rapidly it progresses in loose earth, we must conclude that it is possessed of simply stupendous *strength.* Indeed, the mole is a giant among dwarfs. For putting its digging and scraping tools in action, especially powerful muscles are developed in the anterior part of its body. These are attached to the long *shoulder-blades*, the strong *clavicles* and *bones of the arm*, and the high bony crest of the *sternum.* (Compare with birds.)

Digitized by Google

7. The velvety fur consists of short, close-set hairs, by which—

(*a*) Dust and water are prevented from penetrating to the skin. (Illustrate by dipping a velvet rag in water.)

(*b*) As the hairs are not disposed in a particular direction, the fur is always smooth, and in consequence the animal is not hindered in its movements, whether these be directed forwards or backwards.

(*c*) When we reflect that all animals living in complete darkness are colourless (larva of cockchafer, tape-worm), the *black fur* of the mole must appear surprising. The mole, however, is not exclusively subterranean in its habits, for at night it comes to the surface in pursuit of earth-worms and insects, and while thus occupied is rendered almost invisible by its dark coat.

8. *External ears*, which would impede the animal's progress in its underground passages, are absent. They are not required for the purpose of catching sound, seeing that the soil is a much better conductor of sound than air, and because the whole body of the animal acts as an external ear. The animal perceives the vibrations of the soil in the form of sound waves, as we do those of the air. (Experiment: Stop up your ears so that you can no longer hear the ticking of a watch; now take the watch between your teeth. What do you observe?) The openings of the ear-passages can be closed to prevent the entrance of sand or earth.

9. The *nostrils* at the end of the snout are directed downwards for the same reason (against ingress of sand, etc.).

10. The *upper lip* is not rounded as, *e.g.*, in man, but provided with a cutaneous fold, which is applied to the lower lip. In this way the mouth is firmly closed. (People who are obliged to work much in dusty air are in the habit of fastening a cloth over the mouth.)

11. The *eyes*, which are not larger than a poppy-seed, are completely hidden in the thick fur, and useless to the animal. In its dark subterranean domain there is, indeed, nothing to be seen, and large well-developed eyes would be superfluous.

B. Structure of Body, and Food.

1. *Dentition.*—A glance into the open mouth of the mole at once convinces us of its carnivorous habit; indeed, as a naturalist has expressed it, it is "more carnivorous than the cat or the dog." The canine teeth resemble sharp-pointed daggers, and the crowns of the molars are divided into sharp tubercles, arrangements which indicate that (as in the bat) its food must consist of insects and insect larvæ. It also makes great havoc among mice, and consumes with equal relish frogs and toads, earth-worms and snails.

Digitized by Google

2. The *intestine* is short, like that of all carnivores. (Compare the ox in this respect.)

3. *Mode of obtaining Food.*—As in the case of a blind man, the total absence of sight in the mole is compensated by the exaggerated development of two other senses, viz., the *smell* and the *touch*. The snout is richly supplied with nerves, and, according to naturalists, forms an incomparably delicate organ of touch. The hearing also is excellent.

4. *Habits and Peculiarities.*—As a result of its burrowing mode of life, which necessitates a great expenditure of force, the mole is a very voracious animal. (See bat.) It pursues, in fact, a career of incessant slaughter. The quantity of food consumed daily is about equal to the weight of its own body. If confined to a diet of cockchafer larvæ, it will require a daily supply actually amounting to three or four times its own body weight. This is due to the fact that the intestines of these noxious larvæ contain a large quantity of vegetable food materials as well as of earth swallowed with the food. These useless constituents the mole carefully squeezes out before it devours the animal. In consequence of its own large requirements in the way of food, this insatiable animal tolerates no other member of its own species within its domain; indeed, the mole leads the life of a surly unsocial hermit, and is at all times prepared to defend its own with its last breath.

5. Its *small size* is in accordance with the nature of its food. A large animal, such as a horse or elephant, would not be able to satisfy its needs on a diet of insects or earthworms.

6. *Manner of passing the Winter.*—Whilst other insect-eating species on the advent of winter either migrate to warmer countries (*e.g.*, birds), or pass into a condition of death-like sleep (*e.g.*, bats), the mole continues its pursuit of larvæ and worms in the unfrozen depths of the soil. It is not compelled to enter into the *hibernating stage*, and appears, in fact, during this season to have special facilities for obtaining its food, for after long spells of frosty weather large quantities of earthworms (amounting sometimes to 5 or 6 pounds weight) have been found immured in the walls of the passages adjoining its dwelling. If it killed these animals they would soon putrefy, and thus become uneatable; it therefore very cleverly prevents them from further boring their way through the soil by wounding their head-segments or biting off a few rings from the front end of the body.

C. Plan and Structure of Dwelling.

1. The dwelling of our little miner is found under a heap of earth or hillock much larger than the ordinary molehills. It consists of a rounded cavity or central chamber, which is comfortably padded with

Digitized by Google

moss, leaves or grass. Frequently this central chamber is surrounded by one or two annular tubes or canals, which communicate by passages with each other and with the central chamber. If the dwelling is at a distance from the animal's hunting-ground in a protected spot, as under a wall or a stone heap, a long firmly-built passage, the "run," leads from the chamber to the hunting-ground, which is traversed by burrows in all directions, and can be recognised by the small earth heaps or molehills. If, on the other hand, the central chamber lies right in the midst of the hunting-ground, no "run" is constructed, the burrows in this case radiating directly from the central chamber or the annular canals.

2. About six times a day the mole traverses its wide domain in search of the necessary food. If its hunting-ground ceases to supply a sufficiency of daily food, it proceeds to extend its range; and if the ground is utterly depleted, the animal turns its back upon it and goes in search of "fresh fields and pastures new."

D. Position of the Mole in the Economy of Nature and in Relation to Man.

1. *In Regard to other Animals.*—(*a*) We have already learnt what animals specially become its victims.

(*b*) Like the woodpecker (which see), who works for others beside himself, the mole also is a *useful builder* for other animals. The weasel enters its passages in pursuit of field-mice, whilst the humble-bees, who almost exclusively pollinate the flowers of the red clover, nearly always select the central chamber of the mole for their nests.

(*c*) Foxes, martens, owls and falcons, ravens and storks, lie in ambush for the mole while he is throwing up his earth-heaps, while the weasel pursues him in his underground passages.

2. *In Regard to Man.*—In places where the mole lives principally or exclusively on larvæ and mice, it is without denial the farmer's truest helpmate, for no other animal is so successful in getting at all kinds of underground vermin. On the other hand, where these insect pests are absent and the mole consequently relegated principally to a diet of earthworms, it undoubtedly inflicts much damage, inasmuch as these worms (which see) are of the highest value in working the soil. Nevertheless, earthworms sometimes appear in such numbers that they destroy whole crops, after they have been sown, by pulling the young plants into their tubes. In such cases the mole once more renders good service. Indeed, it is true of this animal, as of many others, that it is *useful in one place, destructive in another.* Accordingly, an intelligent gardener or

Digitized by Google

farmer, before getting rid of the mole, should carefully balance against each other its uses and the damage it inflicts. In no case, however, is there any excuse for killing the animal. It is sufficient to drive it out if it becomes a nuisance (*e.g.*, from gardens), for there is plenty of good work left for it in the meadows and the fields. The best way of getting rid of it is by sticking bits of the green stalks of the elder (*Sambucus*) into its runs, or laying about the heads of herrings, or rags dipped in petroleum, such objects being highly offensive to its refined sense of smell. It often, however, burrows only a little farther off, and the nuisance is as bad as before. From garden beds it is best kept off by putting in thorns, which injure its sensitive snout.

E. Distribution.

The mole is found throughout almost the whole of Europe, in North Africa, and in the western part of Northern and Central Asia. It cannot, however, exist in districts where the soil freezes to a great depth, or where it is very swampy or sandy or subject to being flooded (why not?); and the same holds good for districts where, owing to the burning heat of the sun, the soil is parched to a considerable depth, resulting in the destruction of all vegetable life, and, therefore, of all animal life underground.

Family 2: Shrews (Soricidea).

The Common Shrew (*Sorex vulgaris*).

(Body 2½ inches, tail ⅘ inch long.)

In its mode of life this animal resembles the mole. Its fore-limbs, however, not being widened out into shovels, it is much inferior to the mole in the art of digging and burrowing. Its "runs," accordingly, are only just below the surface of the soil, and it even prefers the natural clefts and rents in the soil or the ready-made passages of the mole. From its underground life, we may explain the velvet-like character of its *fur*, the small size of its *eyes*, the fact that the *ears* are capable of being closed, and the highly-developed sense of touch located in the nose, which here also is prolonged into a snout or proboscis. Its *coat* varies in colour from reddish-brown to black, the belly only being grayish-white. This colour, as well as its strong, musk-like scent, serve it as excellent means of protection against its enemies. Its teeth point it out as pre-eminently an insect-eater. According to a naturalist, "if these teeth were magnified to the proportions of those of a lion, they would represent a truly terrible instrument of destruction." Another observer, speaking

Digitized by Google

of the voracity of shrews, says: "It is most fortunate that shrews are not as large as lions, otherwise they would depopulate the whole earth, and finally themselves die of hunger." These useful little creatures are to be found in wood and field, hill and valley. In the *winter* they are fond of visiting stables and barns, where they actively engage in the pursuit of mice.

A closely-related species is the **Water Shrew** (*Crossopus fodiens*). As its name implies, it is pre-eminently an inhabitant of the water, and as such an excellent swimmer. By means of the long hairs on its hind-feet, which can be spread out in comb-like fashion, these limbs are made to serve as effective oars. On land these hairs are applied closely to the skin; the animal is thus not impeded in its movements, whilst the hairs themselves are protected against wear. The presence of a hairy comb on the under side of the tail converts this organ into a rudder. The thick fur (see otter) prevents the water from penetrating to the skin. Apart from insects and their larvæ, small fish form its principal nutriment.

Family 3: Hedgehogs (Erinacei).

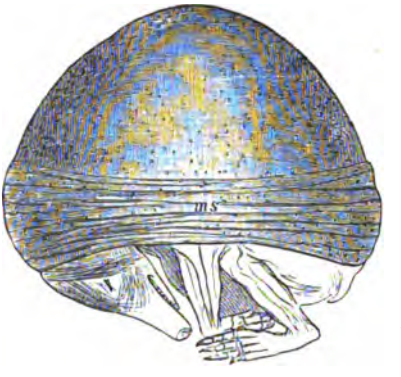
The Common Hedgehog (*Erinaceus europæus*).

(Length about 12 inches.)

Judging from its dentition, the hedgehog appears to live principally on insects and small vertebrates. By reason of its larger size, its short burrowing snout and its prickly armour, it is not fitted for an underground existence like its relatives the mole and the shrew; but is able, by the help of its *snout* and its strongly-clawed toes, to dig after mice, to rummage among the leaves after insects, worms and snails, and to build an inartistic dwelling in the earth under thick bushes. This animal deserves our protection, being a zealous destroyer of mice and vipers, the sting of which has for it no more serious consequences than a pin-prick has for us. Still, on occasions it gives offence by seizing a young bird from its nest near the ground, or perhaps a young chick from the poultry-yard, or even by taking toll from the windfalls of our orchards. Its life being passed above ground, its eyes are also much larger than those of its two near relatives, and the ears cannot be closed. It has neither great bodily strength for defending itself against its enemies, nor is it able to evade them by rapid flight. Consequently it is timid, and afraid of the light, generally passing the day concealed in its hole. Indeed, this plump, awkward creature would long since have disappeared from the face of the earth if it did not possess excellent means of protection in its *earth-*

Digitized by Google

coloured coat and the *prickly armour* which covers the upper portion of its body. On the approach of danger, it rapidly rolls itself together into a ball; the head, legs and under side of the body, which are without spines, are enclosed within the spiny skin of the back, and the animal now presents a thousand small spears towards its would-be assailants. This peculiar action is due to the presence of a muscular ring, which when the animal is in its extended state lies flat over the back, but in the act of "rolling up" is pushed downwards, as it were, "below the equator" of the animal's body. The prickly skin of the back, being connected with this muscular coat, shares in its displacement, and in this way completely covers over the unprotected parts of the body. By means of this action the spines, which are really nothing but specially strong hairs, are at the same time erected. These spines now no longer all lie in one particular direction, but point promiscuously in all directions, so that they can no longer be depressed by an attacking party. Dogs and foxes only come off from the attack with a bleeding snout, but the horned owl is not so easily terrified. With its long, sharp claws and powerful beak, it actually penetrates, without fear of injury, the armour of spines, and kills the hedgehog. The spiny armour is a further protection to the animal, when it happens to fall from a high wall or cliff, a danger to which a creature of its awkward gait is not infrequently exposed. In such an emergency, it quickly rolls itself up, and the spines break the force of its fall by their elasticity. Lastly, the prickly coat serves as a comfortable means of transport, for by rolling about on the ground the animal impales on its spines such objects as leaves, moss, etc., and in this manner conveys them to its winter home. Here, rolled up (as a means of preservation of body-heat; see badger), and well fed (see bat), it sleeps through the cold, barren season of the year.



HEDGEHOG WITH THE SKIN REMOVED.
(One-fifth natural size.)
Ms., Muscular ring.

ORDER VII.: RODENTS (RODENTIA).

Dentition: A pair of rootless incisors in each jaw, the anterior surfaces of which only are covered with enamel; in the hare family alone there is a second smaller pair of incisors in the upper jaw. The molars have

Digitized by Google

transverse ridges coated with enamel, and are separated from the incisors by a *wide gap*. Canine teeth absent. Toes usually five on each foot, provided with claws.

Family 1: Squirrels (Sciuridæ).

The Common Squirrel (*Sciurus vulgaris*).

(Length of body about 10 inches; length of tail about 8 inches.)

A. The Squirrel is an Arboreal Animal, a True Creature of the Woods.

1. The squirrel is an agile jumper by reason of *its long and powerful hind-legs and its supple body* (see cat). It can cover in one leap a distance of as much as 13 to 16 feet, and can spring not only from branch to branch, but even from the crown of one tree to that of another.

2. In these performances it is materially assisted by the structure of its *feet*, the toes (five on the hind-feet, and four on the fore-feet) being long, and not united with each other, but free (like the fingers of our hand). Consequently it can with ease and safety hold fast to the boughs of trees and grasp thin branches. Even in the swaying crowns of the trees or at the ends of branches, still vibrating from the force of its leap, the squirrel maintains as firm a hold as man on the level ground.

3. In leaping, the *tail*, which is almost as long as the body, and covered with a double row of hairs, forms an excellent rudder. It, moreover, acts as a parachute, breaking the force of its fall, in case the animal should drop down from a tree or be obliged, in fleeing from a pursuer, to take a downward leap from the summit of a tree to the earth. In such an emergency, the animal extends its limbs horizontally from the body in order to present to the air as large a surface of resistance as possible.

4. The long, sharp *claws* of its toes, by which it can firmly hook itself to the bark of trees, further enables it to climb with a skill unequalled by any other of our native animals. Even smooth-barked trees, such as the beech and birch, it ascends by leaps, with remarkable speed and surety.

B. The Squirrel as a Rodent.

The trees of the forest provide the animal with its food. This consists of acorns, beech-nuts, nuts, the seeds of the pine and fir, young juicy shoots, buds, berries, fungi, and the bark of branches, according to what the forest or the season of the year can supply. For getting at the hard kernels of nuts or gnawing, *i.e.*, cutting off in small bits the hard bark of trees, it is provided with—

1. *Incisors*, or gnawing teeth, as they are called, from their mode of

Digitized by Google

action. A pair of these is present in each jaw. By allowing the animal to use its teeth on a slab of wax, the impressions will be found exactly to resemble those made by a chisel, or, rather, a fluting plane. *We are, in fact, really dealing with small chisels or a planing tool.*

(*a*) If it is desired to pick small pieces from the flat surface of a board with a chisel, it is usual to place the tool at as acute an angle as possible (why?), and deal the handle a heavy blow, when a splinter will be detached. For the same reason, also, the incisors of the squirrel should form as acute an angle as possible with the object to be gnawed. This is effected by their *being very strongly curved.*

(*b*) The front-teeth, having to perform severe work, must be set deeply and firmly in the jaws; and, in fact, the parts *inserted in the jaws are very long*, far longer than those which project; in the case of the lower incisors they extend back behind the molar teeth.

SKULL OF SQUIRREL. (Natural size.)

(*c*) By constant use, even the strongest steel instrument is worn away. In the same way, the incisors of the squirrel wear away in time, and would finally become so short as to be useless for their purpose. Accordingly, they *are constantly renewed at their inner ends in proportion as they are worn away.* The portions of the teeth embedded in the jaws are constantly being pushed outwards from their curved sockets; consequently their curvature must be uniform throughout, forming, in fact, a portion of the circumference of a circle. (Why can they not be straight?)

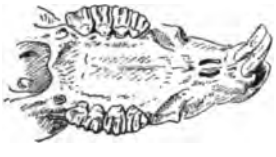
(*d*) If the incisors, like those of man, for instance, were covered all round by enamel, they would soon wear away in an equal degree against hard objects, *i.e.*, become blunt. Here again the resemblance to a chisel or plane is complete, for just as, in these instruments, only the cutting-blade consists of steel, so in the rodent teeth only the outer side is coated with a thick plate of enamel; all the rest of the tooth consists of softer osseous material. By the gnawing of hard objects this osseous material is worn off more easily than the enamel layer of the cutting surface; the latter consequently remains constantly sharp, and the tooth itself retains its chisel-like form.

2. If the incisors were close to the other teeth, as in man, they would not be fitted for separating a splinter or for penetrating into hard substances, as in opening a hazel-nut or tearing off the scale of a pine-cone. If they were more numerous, the cutting edge would be too broad. (A broad chisel does not penetrate into wood so easily as a narrow one.)

Digitized by Google

The incisors must therefore project freely, and therefore between them and the molars there is a wide gap, or diastema. There are consequently no canine teeth. Nor, indeed, does a herbivorous animal need them.

3. There are five grinding teeth (molars and premolars) on each side of the upper jaw, but the first is rudimentary, and is often last in adult life; in the lower jaw there are four on each side. Now, in order to be digested, all vegetable substances must first be carefully ground up. How is this effected? If the lower jaw were as firmly articulated as in the carnivora (see cat), this would not be possible. In rodents, therefore, the articulating head or condyle of the lower jaw is elongated longitudinally, and glides along an equally elongated articular groove. *The mandibles in chewing, accordingly, move from behind forwards* (sliding movement), *and the molars thus act as files, which grate up the food.* On account of the postero-anterior movement of the mandibles, the prominences of these files, *i.e.*, the enamel ridges (see p. 16), must be placed



UPPER JAW OF SQUIRREL FROM BELOW. (Natural size.)

LOWER JAW OF SQUIRREL. (Twice natural size.) The socket of the incisor is somewhat broken open in front, indicated by a dotted line behind.

transversely to the longitudinal axis of the jaws; and since the osseous portion of the teeth offers less resistance than the enamel ridges, *the file-like surfaces remain constantly sharp.*

4. In order to grind up the food, which is taken in very small bites, only short grinding surfaces are required. The head of the squirrel, accordingly, like that of all rodents, is not nearly as elongated as that of the larger herbivora (see ox, horse).

5(*a*). For gnawing especially strong *muscles* are required, and to work to the best advantage (to shorten the arm of the lever) these muscles must be inserted as far forward as possible in the lower jaw.

(*b*) By this arrangement the *mouth opening* is much contracted; on the other hand,

(*c*) The *upper lip* is divided as a protection against injury in gnawing, and for the purpose of exposing the upper incisors (hare-lip).

6. In order to open a nut or acorn, or to dismember a pine-cone, the

Digitized by Google

squirrel grasps these objects with his *fore-paws* (see Section A, 2). The presence of a rudimentary thumb almost converts these into hands, and thus renders them still more suited for grasping. While eating the animal sits, or rather squats, on the hinder portion of its body.

7. Since the animal uses its fore-limbs as arms, *clavicles* are present. (Compare with bat.)

8. Since it conveys the food to its mouth with its hand-like paws, the *neck* is short. (Compare with orang-utan and ox.)

9. The *salivary* glands are large, as in all herbivorous animals (see ox). The *œsophagus* is narrow and the *intestine* long.

C. Its Enemies.

Among animals the marten is the fiercest foe of the squirrel. The fox, too, endeavours to circumvent it, and falcons and owls swoop down upon it when they have the chance. Man, who takes pleasure in the varied antics of this "monkey of our woods," has long recognised that in the squirrel he is dealing with a serious destroyer of the forest. The forester might perhaps be inclined to overlook the destruction of his seeds, but when he finds the young shoots of his pines and firs bitten off, young trees, which he has reared with much trouble, killed by having their bark gnawed away, the nests of his most useful helpmates, the feathered songsters, despoiled, we need not wonder at his wrath and his endeavours to destroy the spoiler wherever he can. Nature, however, has equipped the squirrel with various means of protection against its enemies.

1. Its *arboreal life* is in itself a protection, for neither fox nor man can follow it to its lofty domain.

2. Its extraordinary *agility*, excelling even the marten (which see) in leaping and climbing. Birds of prey it usually eludes by rapidly climbing up the trunks of the tree in spiral lines, whereas its pursuers can only fly round in larger curves.

3. Its *reddish-brown coat* renders it almost unnoticeable on pines and fir-trees, especially since its lighter-coloured under-side is covered by the stem or branches. In the North (Lapland, Russia and Siberia) its fur during the snowy winter becomes whitish-gray (minever).

4. Its *sharp senses* enable it to detect an enemy even at a distance. With its erected ears, which are provided with a pencil of hairs, the so-called "horns," it can easily detect the slightest sound, and with its keen and watchful eye it constantly surveys from its lofty watch-tower its immediate surroundings. The hairs over the upper lip indicate a well-developed sense of touch.

5. By the aid of the hand-like fore-paws it constructs a protective *nest*

Digitized by Google

out of brushwood. As a rule, this is placed on the main trunk in the fork of a large branch, since from such a situation it can easily effect its escape. The nest is covered with a thick roof against rain and storm, enemies almost as much dreaded as its living persecutors. The main entrance is invariably directed downwards. There is a smaller hole close to the stem, through which it escapes when surprised. In this nest, on a warm and cosy bed of moss, it passes the night. It also serves as a nursery. Occasionally, too, but then only temporarily, it will take up its quarters in the hollow trunk of a tree, or in the abandoned nests of crows and birds of prey.

6. Its worst enemy, however, far severer than even man or marten, is the winter. When the snow has thickly covered the fallen acorns, beech-nuts, hazel-nuts and fir-cones, and the boughs of the trees bend under its load, the squirrel reposes, snugly rolled up (preservation of heat) in its warm nest, the outlets of which have been tightly closed, and bids defiance to the raging storms. Its long hairy *fur* forms an excellent winter coat. Like a wise housekeeper, it has made good provision against hunger during the period of superabundance; for in hollow trees, under tree-roots or stones, or in an unused nest, it has established *store-rooms* richly supplied with food.

7. Nevertheless, during long and severe winters many squirrels perish from cold and want of food, while many others succumb to their animal foes. One would almost suppose that this animal, so ornamental to our woods, would have been long since exterminated. And this would indeed be the case but for its extraordinary *fecundity*. The female has from three to seven young twice in the year, so that by the autumn the family comes to number from eight to sixteen heads.

The Alpine Marmot (*Arctomys marmota*).

(Length of body about 20 inches; length of tail about 4 inches.)

This peculiar animal is found on the highest mountains in the Alps, the Pyrenees and Carpathians, close below the line of eternal snow. The only way in which it defies the long icy winter, lasting from eight to ten months at these altitudes, is by digging with the powerful claws on its fore-paws deep holes beyond the reach of the frost, and by falling into a death-like hibernating sleep. With the end of June, when spring has at last effected entrance into its inhospitable home, and the first juicy Alpine flowers blossom forth, it leaves its hole. By the protection of its brownish-black colour it is not easily recognised even by eagles and vultures. As soon as one of a troop of marmots observes an

Digitized by Google

enemy, it gives a shrill warning whistle, and in a trice the whole flock has vanished into the summer holes (which are less deep) or underneath rocks. Its teeth are of the usual rodent type, and enable it to cut off even the shortest grass, some of which it dries to hay as a padding for its winter dwelling. With the advent of winter the animals in families retire to their holes. To prevent the entrance to the chamber of the death-chilling cold, the passage, 25 to 30 feet long, which leads to it, is closely and firmly walled up from within with stones, earth and hay to a length of from 3 to 7 feet. The air in the chamber is consequently not cooled down to below 10° to 12° C. (50° to 53° F.). The members of the family then lie close to each other in the soft hay, and soon all are buried in deep sleep.

Family 2: Beavers (Castoridæ).

The European Beaver (*Castor fiber*).

(Body up to 2 feet 8 inches long; tail 1 foot.)

Formerly the beaver used to inhabit all the wooded banks of the lakes and rivers of Europe. Incessant pursuit, however, for the sake of its valuable fur, its excellent flesh, and the grease, or castoreum, a fatty, salve-like substance secreted by two anal glands, has long ago exterminated it in Britain and many parts of the Continent. At present it is found in small numbers on the Elbe and its tributaries, between Wittenberg and Magdeburg. In Russia, Scandinavia, Siberia and North America also a war of purposeless extermination is being waged against this animal, which will, in all probability, soon have to be numbered among the "creatures of the past." The beaver is as much at home in the water as below or on the earth, and the structure of the body is in accordance with its varied habits.

A. The Beaver as a Water-Animal.

I. It is provided against a *fatal cooling* of the body, through too long a stay in the water, by the same means as the otter (which see).

II. The structural characters, which enable the otter (which see) to *swim for protracted periods and to dive with skill*, are for the most part repeated in the case of the beaver.

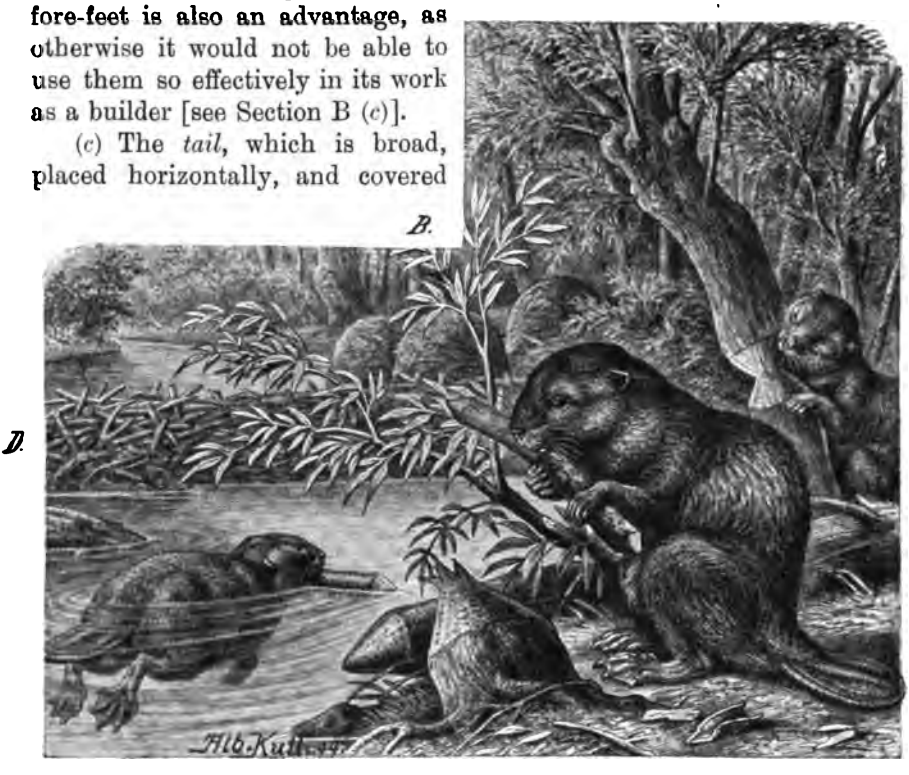
(*a*) Compare what has been said in the case of the otter with regard to air-spaces between the hairs of the fur, the lubrication of the latter, the general form of the body, the importance of the tail, the shortness of the legs, the closure of mouth and nose.

(*b*) The beaver is not nearly so rapid a swimmer as the otter, its body

Digitized by Google

being much stouter, and only the hind-feet being webbed. Speed in swimming, however, is not of such importance to this animal, as it is a peaceful vegetable-eater, and does not, like the otter, feed on animals which flee at the sight of their enemy. The absence of webs on the fore-feet is also an advantage, as otherwise it would not be able to use them so effectively in its work as a builder [see Section B (*c*)].

(*c*) The *tail*, which is broad, placed horizontally, and covered



BEAVERS. B., HUTS; D., DAM.
The animal in the foreground gnawing a branch is about one-fifteenth natural size.

with scales, acts as a rudder. The animal changes its direction, however, chiefly by the flexibility of it vertebral column, especially of its neck, like other swimming mammals.

(*d*) The *ears* are short and nearly hidden in the fur; in swimming they are laid back so far as to close the auditory passage.

B. The Beaver as a Builder.

With the strong claws of its fore-paws it digs an *underground dwelling*. One or more long passages, which terminate below the surface of the water, lead to the chamber, the bottom of which is covered

Digitized by Google

with grass or reeds. Here it spends the day at rest, feeding and working only during the night.

Besides its underground dwelling, the beaver builds up more or less artistic structures in the water out of the trunks of trees, branches and brushwood. How is it enabled to do this?

(*a*) By *means of the powerful incisor teeth*, which in felling trees serve it as an axe. If it wishes to fell a tree, it gnaws round the trunk, especially on the side facing the water, until it bends and falls; trees of as much as 2 feet in diameter have been felled in this manner. The trees are cut in pieces for use in building, unless they are too strong, when the branches are stripped off. The bark and leaves serve as food, the bark of willows, poplars and aspen being specially preferred.

(*b*) While engaged in building the beaver sits erect on its hind-feet, the broad tail serving as an additional support.

(*c*) By means of the fore-paws, which, not being webbed, can be used as hands, it holds tight the branches which it detaches from the tree or from which it is gnawing the bark.

The structures erected by the beaver are of four kinds: (1) If the surface of the water sinks so low as to expose the opening of the passage which leads to its dwelling, the beaver covers it with an interlacing meshwork of brushwood, by which contrivance it is enabled to reach the water without being observed. (2) If in consequence of a heavy fall of rain the thin roof of earth above its chamber should fall in, it covers the opening thus formed with a heap of branches from 7 to 10 feet in height, and in shape resembling a charcoal kiln. (3) Where beavers live in large companies, as is still the case in North America, they erect what are known as "beaver castles" at shallow spots of rivers or lakes. These consist of mounds or heaps shaped like a baker's oven, from 7 to 10 feet in height, and about 10 or 11 feet in breadth, and composed of tree-trunks and branches roughly piled together. These structures are then covered over with sand, mud, earth, reeds and pieces of turf, which the animals carry up in their mouths. In their interior we find, besides the animals' dwelling-places, also store-chambers for the winter, in which they hoard up pieces of bark and all sorts of roots. The European beaver, also, when driven out of its home by floods, builds on land structures similar to these, though much less extensive. (4) If the level of the water of a brook or stream sinks so low that the beaver can no longer move without hindrance in the shallow water, it builds a dam for stemming back the water. Similar structures are erected in lakes and ponds for the purpose of damming up the inflow water. These dams consist of tree-trunks bound together with reeds, osiers, etc., and cemented with mud, clay, etc. It must increase our wonder to learn

Digitized by Google

that in North America these dams sometimes attain to a length of about 600 feet, and a height of from 7 to 10 feet, with a thickness of from 13 to 20 feet at the bottom, and 3½ to 7 feet at the top. The beavers which still exist in Germany no longer construct dams of such extent, and they have also given up building "castles."

Family 3: Mice (Muridæ).

The Marmot, or Hamster (*Cricetus frumentarius*).

(Length from 10 to 12 inches.)

This animal is a native of the steppes which has followed man into the ploughed fields. It is now found from the Ural to the Vosges. In Central Germany it has already frequently made its appearance as a pest. It avoids a sandy or moist soil. Its multicoloured skin, in which a brown-yellow tint predominates, was evidently a safe protection on the steppes against its enemies. Not being able to run as fast as the hare, it seeks protection underground. It digs its hole in the same way as the badger (which see); this explains many other similarities between the two animals, the body being thick-set and sturdy, the feet short, and the claws sharp. The dwelling-place is padded with soft vegetable materials, and lies at such a depth below the ground as not to be reached by the plough. From it a vertical and a sloping passage lead to the surface. Both these passages are bent at their lower ends. (Why? What different purposes do these two passages probably serve?) Besides these, one or more passages lead from the dwelling chamber to the storerooms. The dentition of the marmot is almost exactly the same as that of the squirrel (which see). During spring and summer it feeds on all kinds of vegetables, but when the corn ripens it feeds entirely on grain. Since grain, peas and beans do not spoil during the winter, it carries a store of these (often amounting to half a hundredweight) into its dwelling. By means of its very agile, hand-like fore-feet it bends down the blades and bites off the ears with its incisors; it then, with its paws, draws the ears several times through its mouth, at the same time, with its tongue, pushing the grain thus pressed out into its large cheek-pouches, which extend to near the shoulders. Not being able, however, to carry in sufficient grain for the whole winter, it sleeps through a great part of that season. After having fed abundantly off its store (why?—see bat), and carefully stopped up with earth the entrances to its dwelling, it betakes itself to rest. With the approach of spring it re-awakes. As the fields, however, cannot as yet supply it with sufficient food, it consumes the rest of its

Digitized by Google

stores. The damages this animal inflicts upon the farmer are considerable, especially as it is extremely prolific. For this reason its enemies (the polecat, weasel, and owl) deserve protection.

The **Common House Mouse** (*Mus musculus*) and the **Brown Rat** (*Mus decumanus*) are the best-known, and at the same time best-hated, species of the rodent family. Only hard metals can withstand their sharp, destructive teeth. Even strong walls cannot keep them out of the house, which they infest from garret to cellar. At the same time, they multiply to an almost incredible extent. Their great agility and sharp claws render them adepts at climbing, in which they are further

HAMSTER FILLING ITS CHEEK-POUCHES. (One-sixth natural size.)
To the right the head on larger scale. B., the filled cheek-pouches; E., entrance of pouch.

assisted by their long, slightly-haired, scaly-ringed tail. By means of this organ they prop themselves against any unevenness of the object to be climbed, and also use it for winding round thinner objects. Their dull-coloured coat is in keeping with their mode of life. Their distribution is co-extensive with that of man. The brown rat did not migrate from Asia to Europe until the beginning of the last century. It displaced the dark-brown **Domestic Rat** (*Mus rattus*) so completely—being much more savage and ferocious—that the latter is now but rarely met with.

Family 4: Field Mice (Arvicolidæ).

Of the mice which inhabit our fields and woods we shall only mention the **Field Mouse** (*Arvicola arvalis*), which during dry years

Digitized by Google

(why specially at such times?) makes its appearance often in truly terrifying numbers, and wreaks immense damage.

A closely-related species is the **Water Rat**, or **Water Vole** (*A. amphibius*), which is equally adept at swimming as at burrowing, and which may inflict great damage by gnawing the roots of trees.

Family 5: Hares (Leporidæ).

The Hare (*Lepus timidus*).

(Length up to about 30 inches; height about 11 inches.)

A. The Hare is a Much-persecuted Inhabitant of our Fields.

It is much in demand on account of its excellent flesh. In the words of a German rhyme,

"Man, dog, wolf and lynx,
Cat and marten, weasel, fox,
Eagle, owl, raven, crow,
Every hawk that flies on high,
Nor must magpies be forgot—
All off him a meal would make."

With such a list of foes, it is almost to be wondered at that the hare has not long since been exterminated, especially when we reflect that—

1. It is an almost defenceless creature, that could seriously enter into a combat with but few of the enemies in the above list.

2. Living as it does in the open field, it is much more easily seen by its enemies than if—like the rabbit, for instance—it lived in a hole or burrow, though it does also resort to such cover as is to be found in woods or bushes in the neighbourhood of the fields it frequents (wood or bush hare).

3. In consequence of this mode of life, it is much exposed to the severity of the weather. In cold, wet weather large numbers of young hares are apt to perish.

B. Means of Protection against its Numerous Enemies.

1. The hare becomes aware of its foe even before the latter comes dangerously near. Though its sight and smell are feeble, the *hearing* must be uncommonly acute, for the least noise—a rustling leaf, a lizard slipping past, and the like—will arouse it from sleep. The large ears, too, which are easily movable in all directions—see also Section 3 (*a*)—point to the same fact.

2. The colour of the fur so perfectly assimilates to that of the ground that the hare is easily overlooked by its enemies. When it is at rest in its "form," even a practised sportsman will frequently pass by

Digitized by Google

without noticing the animal, the white of the belly and underside of the tail being concealed. So long as it is of any use the hare sits still.

3. When, however, no longer able to conceal himself, he takes to flight (or "to his heels," as the saying is). In running he really executes a succession of long leaps. The hare is adapted for this mode of progress by the following arrangements:

(*a*) Its *slender shape*, by which it is enabled easily to cut through the air (compare with wolf). To diminish resistance to the air as much as possible, the long *ears* in running are laid backwards, which at the same time enables it to judge of what goes on behind it.

(*b*) By a sudden stretching of the long and powerful hind-legs, which are always moved together, the body is propelled a considerable distance (compare with cat). Even the slowest movement of the hare is a jump. This great length of the hind-legs also enables the hare to run up a hill with ease, but in running downhill it is very apt to tumble. (Locate the position of its centre of gravity.)

(*c*) The vertebral column is *very flexible* (see under "Cat," p. 27, where it is compared to a cane). This is a great advantage to it in leaping, and also enables it easily to alter the direction of its course—to "double," as it is called—when an enemy, *e.g.*, dog, comes too close. (Explain the importance of "doubling.")

(*d*) By means of its powerfully clawed toes it is able to obtain a firm foothold among the inequalities of the ground when taking its spring.

(*e*) The *tail* is short, not being used as an aid in leaping, as in the case of arboreal animals like the squirrel or marten, nor as a means of support, as in the kangaroo.

4. All these various protective arrangements, however, would fail to save the hare from extermination were it not for its extreme *fecundity*. From April to August the female brings forth young four or five times, and from two to five at a birth. Thus, there is a saying in Germany: "For every hare that goes into the fields in spring, sixteen return in the autumn." If they continued to multiply unhindered in this manner, a single pair would in a few years increase to millions (show by calculation). The result would be a complete devastation of our fields. The female hare, however, is a careless mother, with the result that many of the young perish, while the weather and numerous enemies largely reduce the number of the survivors.

C. Mode of Life and Food.

1. Being weak and helpless, it naturally follows that the hare is also a *timid* creature. During the day it rests in some safe hiding-place in a

Digitized by Google

corn or turnip field, or sometimes in a shallow depression in the ground, the "form," which it digs out with its strong claws. When Night spreads her protecting mantle, it goes forth in search of its food.

2. Cabbages and turnips form its favourite food, but it does not despise any other of the fruits of the field. When winter, however, has covered the fields with snow, it has frequently to put up with "short rations." As long as it can scrape away the snow and get at the young corn or the clover, it may manage to get through fairly comfortably. If, however, the snow accumulates or freezes, it has to endure the straits of hunger, and is then often driven into the neighbourhood of human dwellings. Under these circumstances it is compelled to live on the dry bark of trees, which it detaches with its large incisors (gnawing of fruit-trees).

3. The *teeth* in plan and structure resemble those of the squirrel. The only important difference consists in the presence of two small additional lateral incisors behind the median incisors of the upper jaw. In closing the mouth these teeth meet the lower incisors, and thus prevent the gum from being injured.

4. The upper lip is divided, as a protection from injury while gnawing bark or plants of low growth (see squirrel).

5. The fore-feet have the form of paws, not hands, as in the squirrel, since the hare bites off its food, and does not require to hold it like the former. Moreover, fore-feet constructed on the type of a hand would be an impediment to it in running. (Why?)

D. Distribution.

The hare is an inhabitant of the whole of Central Europe and a part of Western Asia.

Related Species.

The nearest relative of our common hare is the **Alpine Hare** (*L. variabilis*). It inhabits the High Alps and a great part of Northern Europe. Its coat in the summer is of an earthy colour, but in winter becomes snow-white (protective colouring). In the mild climate of Ireland, however, it does not assume this winter coat, and in the extreme north it is white all the year round.

The **Rabbit** (*L. cuniculus*).—The rabbit, by preference, takes up its abode in sandy places, digging holes or burrows, with many ramifications, on sunny slopes, which it leaves at nightfall for the purpose of feeding. It has been domesticated on account of its excellent meat and its great fecundity (as many as sixty young being produced in a year). In consequence of this great reproductive power, their habit of living

Digitized by Google

in underground burrows (a protection against the effects of bad weather), and the care of the mother for the young, rabbits multiply so fast that they may even become a pest to the farmer. Thus, within recent years they have spread over some districts in Australia like swarms of locusts, owing to the insufficiency of beasts of prey, which might have checked their astonishing increase in numbers (compare with sparrow). By destroying all the grass, they have actually rendered cattle-rearing impossible, and in this way driven numbers of settlers from their homes. Like a ruin-bringing cloud, they are still spreading over larger and larger districts. By gnawing the bark of trees and undermining the soil, they also do much damage to young plantations in Europe.

ORDER VIII.: PROBOSCIDIANS (PROBOSCIDIA).

LARGE animals having their snout prolonged into a trunk, or proboscis. The legs are pillar-shaped, the toes united, forming a pad. The upper incisors have the form of tusks; no canine teeth; large molars composed of a number of transverse plates.

The Indian Elephant (*Elephas asiaticus*).

(Height from 11 to 13 feet.)

To understand the extremely peculiar structure of the elephant, it is necessary to know the conditions under which the wild animal lives.

A. Its Home.

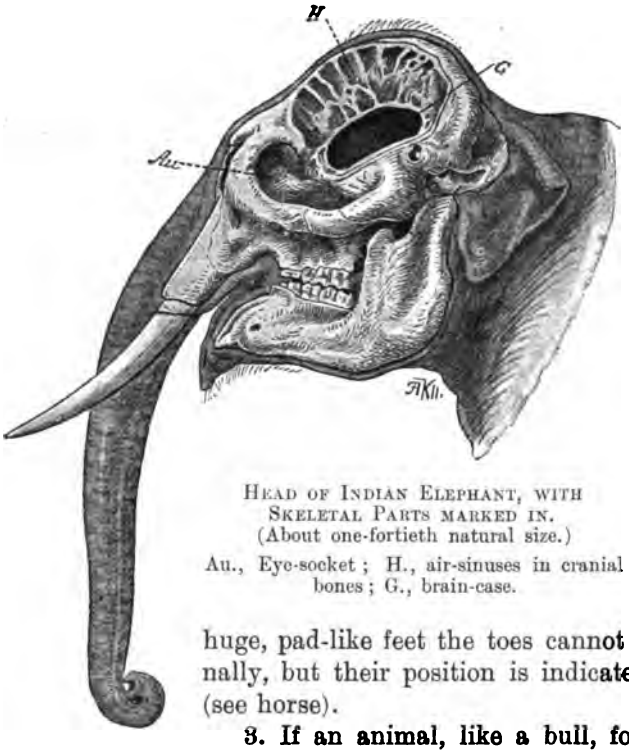
The elephant is found in the immeasurable forests, stretching from the plains high into the mountains, of India, Further India, and the neighbouring islands of Ceylon, Sumatra and Borneo. Here warmth and moisture produce an exuberance of vegetable life. A dense tangle of underwood extends between the lofty trees of the forest. Twining plants of the thickness of a man's arm wind themselves round trees and shrubs, forming an impenetrable jungle. Such mammals as can exist in a jungle of this character must either be arboreal in their mode of life, and able to make their way from branch to branch and tree to tree, or small ground animals, able, on account of their minute size, to creep through the thicket, or, finally, huge giants like the elephants, capable of forcing a passage through the tangled wilderness.

B. What enables the Elephant to penetrate the Aboriginal Forest.

1. The *powerful* body, shaped like a gigantic wedge, which is able to break the thicket asunder. *This body, moreover, is rigid and laterally*

Digitized by Google

compressed. (Could a lion, with its pliant backbone, or a bull, with its stout, round body, even if these animals were of the size of an elephant, perform this task?) Twining plants thick as a man's arm, and even fairly strong trees, are broken by the force of its onrush. Some conception of the strength of this animal may be formed from the fact that a strong tame male can carry a load of nearly a ton.



HEAD OF INDIAN ELEPHANT, WITH SKELETAL PARTS MARKED IN. (About one-fortieth natural size.)
Au., Eye-socket; H., air-sinuses in cranial bones; G., brain-case.

2. The *pillar-shaped legs*, which support a body sometimes weighing nearly 3 tons, trample down bushes and brushwood, while the *feet*, like sledge-hammers, stamp down the underwood to a level with the soil. In these huge, pad-like feet the toes cannot be recognised externally, but their position is indicated by hoof-like nails (see horse).

3. If an animal, like a bull, for instance, provided with a hide by no means thin, endeavoured to break through the jungle of the Indian forest, it would sustain so many wounds and injuries from thorns or broken and projecting branches that it would finally succumb. The elephant, however, is equipped with a *skin as strong and stiff as a board*, forming an armour which neither thorns nor branches can penetrate.

4. The *skin is almost naked;* only here and there a few hairs are found. The reason of this absence of hairs is simple, since, if present, they would soon be lost in the animal's rushes through the jungle of the aboriginal forest. Moreover, living as it does in hot countries, the elephant needs no special means for the preservation of its body-heat (compare with mammoth, Section D.).

Digitized by Google

C. The Elephant a Herbivorous Animal.

1. Requiring as it does an immense amount of food, the mouth of the elephant is furnished with gigantic *molars* for crushing the same. There is, however, only one of these teeth in each jaw, though its size (about 16 inches long and nearly 4 inches broad) makes up for the paucity in the number of these teeth. They are, in reality, compound teeth, each being composed of several transverse plates. As they are worn away by constant use, they are replaced by others, which are developed behind them, and continuously pushed further forwards.

2. The muscles by which these teeth are set to work must be of equally gigantic size. Moreover, the tusks referred to below (in § 5) require to be firmly seated. These conditions explain the size of the head. The bones of the skull are of uncommon thickness, causing the head to appear extremely high, and also affording adequate surfaces of attachment for the muscles. To prevent an unnecessary increase in the weight of the skull, these bones contain air-cavities of dimensions not met with in any other mammal.

3. Mammals which are obliged to pick up their food from the ground (compare them with arboreal, aerial and aquatic animals) must either have a neck of sufficient length to enable their mouths to reach the ground, or they must be furnished with prehensile, hand-like fore-limbs, by which they may convey their food to the mouth. Now, the fore-limbs of the elephant are not adapted for performing work of this kind, and we can imagine what enormous muscles would be required to move the skull with its huge tusks, if the latter was attached to a *long* neck. Accordingly, the task of conveying the food to the mouth is consigned to the *trunk*, or *proboscis*, which is nothing more than an elongation of the nose. The nasal septum extends to the tip of the trunk, which is developed into a very movable, finger-like appendage. A large number of muscles impart to the trunk its extraordinary mobility and extensibility. It is not only an organ of smell, but also of touch and of prehension. By its aid the elephant can pick up tiny objects from the ground, as well as tear stout trees up by their roots. It uses it for tearing huge bunches of grass from the earth or of twigs from the trees, and can even break off with it and convey to its mouth branches as thick as a man's arm. It also uses it for sucking up water, which it then squirts into its mouth or over its back as a cooling shower-bath. Thus, the trunk is to the elephant finger, hand and arm combined. Its presence is really indispensable to the animal, on account of—

4. The *shortness of the neck*. The extraordinary mobility and pre-

Digitized by Google

hensile power of the trunk, in fact, compensates for the *awkwardness* which characterizes all the other movements of the animal.

5. The elephant seizes with its trunk the trees and branches which it wishes to break off only at *one* point. Being elastic, this would cause them to bend, though hardly to break. There must be some resistance against which they may be *broken*. This is supplied by the two powerful *tusks* which project far out from the animal's upper jaw. These tusks are without roots, and grow from permanent pulps, so that each of them may reach a weight of as much as 100 pounds. The trunk and the tusk, as well as the feet, are also used as weapons of defence against the elephant's chief enemies, the tiger and man.

6. From man it retreats with shyness. By means of its *keen scent* (proboscis) it can discover the presence of its most dangerous enemy even at a distance. Every sportsman speaks of its *sharp hearing*. The large, fan-shaped ear-flaps, when erected, act as gigantic ear-trumpets, catching even the slightest noise. The eyes are small, indicating *weak sight*. The *sense of touch* at the end of the proboscis is of uncommon fineness.

D. Importance of the Elephant in the Economy of Nature and to Man.

In its native forests it of course does no damage. On the other hand, a herd of elephants breaking into a plantation lays waste everything before it. In India the animals are hunted mostly for the purpose of taming them and training them to carry heavy loads; they are in that country but rarely killed for the sake of their tusks, which furnish valuable ivory.

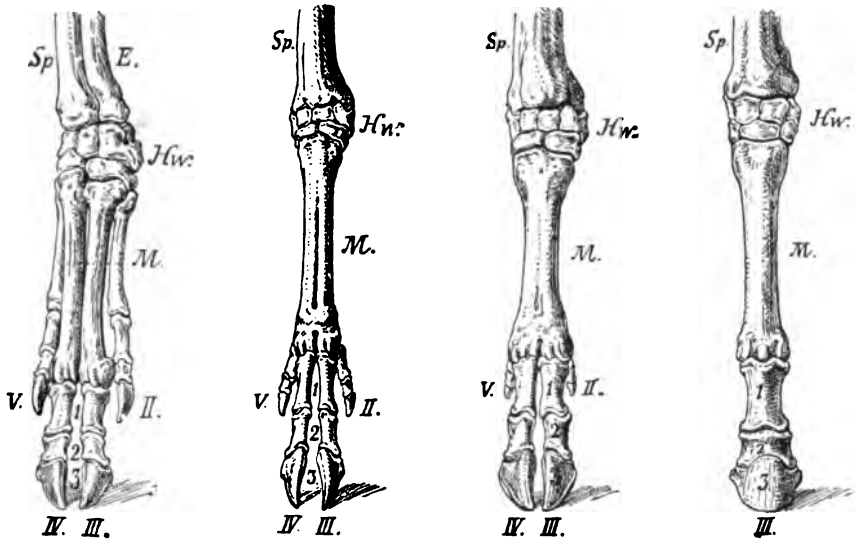
It is quite otherwise with its relative, the **African Elephant** (*E. africanus*), which, for the sake of the tusks alone, is shot down unsparingly, and will probably be soon exterminated. Its ears are even larger than those of the Indian species. Large quantities of ivory are also obtained from Siberia. This is derived from the extinct mammoth, which has been found in a good state of preservation—even the flesh had not putrefied—in the frozen soil of the northern part of that country. The tusks of this primeval giant are curved, and attain to a length of about 13 feet, and a weight of about 160 pounds. The skin of this creature was covered with a thick fur. (Why?)

ORDER IX.: EVEN-TOED UNGULATES (ARTIODACTYLA).

Only one pair of toes—the third and fourth toe—touch the ground in walking (exception, the hippopotamus, which walks on two pairs). The

Digitized by Google

terminal joints of the toes are hoofed. The other toes are either rudimentary or absent.



PIG. DEER. OX. HORSE.

STRUCTURE OF FOOT IN EVEN- AND ODD-TOED UNGULATES.

Sp., Radius; E., ulna; Hw., carpal bones; M., metacarpal bones; II. to V., digits, 1, 2, 3, phalanges. The figures show how the metacarpal bones are more and more united, and the lateral toes more and more reduced.

Sub-Order 1 : Non-Ruminants (*A. non-ruminantia*).

All three kinds of teeth developed in both jaws, the canines often enlarged into powerful tusks. Do not chew the cud, or ruminate. Horns or antlers absent. Body stout. The skin only sparingly provided with hairs or bristles. A considerable layer of fat frequently present under the thick skin.

The European Wild Boar (*Sus scrofa*).

(Length up to about 6½ feet; height up to shoulders about 3 feet; weight up to about 400 pounds.)

The wild boar prefers for its habitat swampy forest thickets, which are avoided by all other native mammals. Hence it is hardly surprising that in the structure of its body this animal exhibits marked differences from all the other habitants of the forest.

Digitized by Google

A. The Boar as an Inhabitant of the Forest.

The wild boar, like the elephant (which see), is capable of forcing its way through the thickets and undergrowth of the forest. It is equipped for this purpose with—

1. A conical head, which it pushes like a wedge through the bushes. Through the opening thus formed it next advances its *rigid, laterally compressed body*, which forms a second and still larger wedge. In this manner, with "lightning speed," as we are informed by a careful observer, the animal rushes through thickets quite impenetrable by any other creature.

2. By means of the *short, powerful legs* and the two middle toes, which are encased in strong *hoofs*, the animal is enabled to obtain a firm purchase against the ground. (Would an animal with long legs and hoofless toes be able to do this?) The two other toes are shorter and weaker, and do not touch the ground.

3. The *skin is very tough*, as a protection against injuries which might be sustained while breaking through the thicket (compare the so-called "rind of bacon" from the domestic pig).

4. The *coating of bristles* which covers the skin becomes also intelligible in relation to this habit of the animal of breaking through thickets. (Could you imagine a sheep, for instance, forcing its way through dense underwood?)

5. The small, strong eyes are deep-set, and surrounded by dense growths of bristles.

6. The thicket of the forest affords these animals, and more especially their still defenceless young, a *safe protection* against their enemies.

B. The Boar as an Inhabitant of the Marsh.

Water is one of the necessary conditions of the life of this animal. It evidently delights to wallow in swamps.

1. *How is it prevented from Sinking?*—(*a*) By the separation of the broad central toes, the area of the surface of support is increased (compare with camel). This happens even on hard ground, but still more on mud, because the latter penetrates between the toes. When these toes sink in further, the smaller hind toes reach the ground, and give further support.

(*b*) By again bringing the toes together into their normal position, the animal, on sinking in a swamp, soon *manages to liberate its feet.* For a man this is a much more difficult performance, for on raising the foot a vacuum is formed below its surface. The two-toed ox can also walk on swampy meadows, but not the one-toed horse.

2. *Why weltering in Swamps for Hours does not induce an Excessive Cooling of the Body.*—(*a*) Under the skin is a thick layer of fat (the

Digitized by Google

"lard" layer of our domestic pig), which acts as a bad conductor of heat. Fat being, moreover, of less specific weight than water, this layer also materially assists the animal in swimming (compare seal).

(*b*) The bristles dry quickly, so that little heat is lost.

3. The *skin* in colour resembles the swamp which the animal inhabits. When reposing in the hole which it digs out for itself, it is very apt to be overlooked by a sportsman. In the young, which are numerous, the skin is marked with lighter or darker stripes. Residence in swamps, which beasts of prey do not venture to traverse, in itself forms a protection for this animal.

C. The Wild Boar is an Omnivorous Feeder.

Its food consists of anything that is eatable—fungi, acorns, nuts, beech-nuts, wild fruits, also all kinds of insects and their larvæ, snails, worms, mice, and even carrion. In winter it has, as a rule, to put up with roots. Setting out for the fields at night, it digs up potatoes and turnips, and consumes cereals and anything else it can find. What it eats, however, amounts to much less than what it digs up and tramples under foot. Thus, the boar is both an animal and vegetable feeder, or omnivorous. Accordingly, we find that—

1. The crowns of the four anterior *molars* are sharp as in carnivores (see cat), and, on the other hand, the three hinder are broad with tubercles almost as blunt as in herbivorous animals (see ox). In fact, so far as its molars are concerned, the pig occupies an intermediate position between these two groups.

2. The *incisors* (six above and below) are large, and hence adapted for biting off small pieces from a large object (*e.g.*, a turnip). Inasmuch as they point obliquely forwards, the animal is able by their aid to pick up small objects from the ground (*e.g.*, acorns, larvæ) or to pull them from out of the soil.

3. The boar leaves its thicket in search of food only under the cover of night. Hence its sense of *hearing* is very sharply developed. The sight, however, is *weak*, as is sufficiently indicated by the eyes, which are not bright as in most animals. Its keen sense of smell and the great sensitiveness of the snout enable it to detect anything eatable to be found in the ground. (The domestic pig has been trained for finding truffles.)

D. The Wild Boar as a Burrowing Animal.

Let us now see how the animal is able to break roots, dig up bulbs, get at underground larvæ, etc.

1. The *head* has the shape of a long, pointed wedge, owing chiefly to prolongation of—

2. The *nose into a snout, or proboscis*, which is supported by the long

Digitized by Google

nasal bones; the nostrils are placed at its anterior end on the terminal burrowing disc.

3. The *canine teeth* are developed into powerful tusks, both those of the upper as well as the lower jaw being directed upwards. Its wedge-like shape and the presence of the powerful tusks render the head an instrument equally adapted for ploughing up the ground and for lifting up roots as thick as a man's arm as easily as with a crowbar. It forms, in fact, a lever, the moving power of which lies in—

SKULL OF WILD BOAR. (One-tenth natural size.)

4. The powerful muscles at the *nape of the neck*, which are attached to—

5. *Very long spinous processes* of the cervical vertebræ.

6. The very large posterior surface of the skull projecting far backwards forms a requisite surface for the attachment of these muscles to the head (compare, on the other hand, the shape of the skull of the domestic pig).

7. The *neck* is short and thick-set, and hence does not bend under the violent labour performed by the head.

8. The mode of feeding explains the distribution of wild swine. In regions where the ground is frozen a great part of the year the animal cannot live. Therefore it does not extend beyond 55° N. Lat. It occurs in Southern and Central Europe, North Africa, West and Central Asia.

E. The Position of the Wild Boar in the Economy of Nature and in Regard to Man.

1. *Enemies.*—Since the total extermination of the wolf and lynx, the only surviving enemy of the wild boar is man. The fox may perhaps be added, though he only ventures to attack the young animals. In southern countries the larger felines prove dangerous enemies. When attacked, the wild boar defends itself in blind rage with its powerful tusks. These weapons, at every movement of the lower jaw, are whetted against each other, and thus remain constantly sharp and pointed. Corresponding to the direction of the tusks and the general structure of the body, the blows dealt out by the wild boar always proceed from below upwards. A single blow suffices to rip open the belly of a dog.

2. *Damage and Uses.*—We have already hinted what damage a herd of wild boars can wreak on the farmer in a single night. Consequently, this species is not, like other game, accorded the benefit of a

Digitized by Google

"close time," and, indeed, in many districts it has already been exterminated. Nor is it looked upon with any favour by the forester, inasmuch as it inflicts serious damage on the trees by tearing off the roots, and destroys plantations made with much care and trouble. It must be conceded, on the other hand, that by incessant burrowing it destroys an immense quantity of injurious insect larvæ, and at the same time, by burying underground the fruits of the trees, it brings about involuntarily a sort of natural sowing of the forest. The only one who would regret the total disappearance of this animal is the sportsman, whose great joy it is to bring down with a sure shot a "fine tusker," a full-grown boar. (The female is called "sow." To what uses is the dead animal turned?)

Related Species.

All the species of wild boars multiply very rapidly, and are easily fattened if well fed and kept inactive (compare with ox). They have, consequently, for thousands of years been domesticated by man. By a constant selection of the best animals for propagation, our **Domestic Pig** (*Sus domesticus*) has been developed, as well as its many varieties (compare the formation of breeds of the dog). In the domestic pig the skull is shorter and higher and the hairs fewer than in the wild boar. The ears are dependent. (How do you explain these deviations?) The descendants of pigs which have returned to the wild state reassume the form and structure of their ancestral parents (compare with dog and cat). The manifold uses of the pig are too well known to need description. But as the host of the trichina and of the scolex or cysticercus of a tape-worm (*Tænia solium*)—"measly" pork—it may become a source of great danger to man.

A more distant relation of the pig is the **Hippopotamus** (*Hippopotamus amphibius*), an inhabitant of well-watered districts south of the Sahara. As its name implies, its true home is in the water, which it leaves unwillingly and exceptionally. The body, too, is adapted to its generally aquatic habits. Its huge, unwieldy mass can only be moved with any speed or precision in water, which bears a large part of its weight. The disproportionately short legs, which terminate in toes united by webs, serve both as oars and rudders to this colossal creature. The neck, as in all other aquatic mammals, is short. The nostrils, which can be closed, and the eyes and ears, lie high up in the skull, so that the animal needs only to raise the upper part of its immense head above the surface of the water in order to breathe or observe what goes on around it. (Compare what is said in the same respect regarding the Greenland whale, the seal, the otter, and the

Digitized by Google

beaver.) The water provides the animal with its food. By means of its powerful incisors and canines (which latter furnish excellent ivory) it tears up by their roots from the bottom all kinds of plants, which it crushes between the large molars of its gigantic jaws. If unable to find sufficient food in the water, the animal is compelled to ascend to the land. The feet have broad "soles," formed by four toes of equal length, which are united by webs and can be spread asunder; these enable it to stride even across mud and sand (compare with wild boar and elk). The hide is about ¾ inch in thickness, almost naked, and of a reddish-brown colour. From it are made the thongs or whips of which we hear so much in countries where the slave-trade still prevails.

Sub-Order 2: Ruminant Artiodactyles, Ruminants (*A. ruminantia*).

Incisors and canines usually absent in the upper jaw. Ruminate, or "chew the cud." Stomach consisting, as a rule, of four divisions. The head is usually furnished with horns or antlers. Body covered with stiff or woolly hairs.

Family 1: Hollow-Horned Ruminants (Cavicornia).

The Ox (*Bos taurus*).

A. Its Origin.

At the time of the ancient Germans, according to Roman writers, two species of wild horned cattle lived in Central Europe: viz., the **Bison** (*Bison europæus*) and the **Urus**—or, really, **Auerochs**—(*Bos primigenius*). Both species still existed in considerable numbers in the Middle Ages; but as they were an obstacle to agriculture, they were destroyed in constantly increasing numbers. At the present time the bison is almost extinct. Leaving out of consideration some that are kept in several large zoological gardens, a few hundred only are still preserved in the aboriginal forests of Bjelowjesha in Lithuania, while a few herds in the wild state are still to be found in the most inhospitable parts of the Caucasus range. The urus survived in Poland till the sixteenth century; in Germany it has been extinct since the year 1100, but in the form of our domestic ox, which naturalists have recognised as a descendant of that primeval giant, it survives to the present day, and will probably prolong its existence far into future ages.

The urus was domesticated long before the beginning of history. By the constant selection for propagation of individuals most useful for his purpose (compare dog), man, in the course of thousands of years, has succeeded in transforming the urus into the domestic ox, numerous varieties of which are now spread, as the most important of domestic animals, over a great portion of our earth.

Digitized by Google

B. Structure of Body.

The body of every animal must be so constructed that it may be able to obtain the necessary food for its own maintenance and that of its young, and also may be capable of protecting itself against its enemies and the influences of weather and climate; for unless these conditions are fulfilled it is doomed soon to disappear from the earth. Man, however, by taking the ox under his protection, has relieved this animal from either of the above-named functions, and in order to understand its structure in reference to them we must consider only such animals of the species as still live under *natural* conditions, or, at least, such surroundings as deviate but slightly from a state of nature. As examples of such we may cite the wild oxen of South America and the semi-savage cattle of the Hungarian Pussta. These animals are left to seek their own food, and to engage in a constant struggle for life with the larger beasts of prey.

FORE-LEG OF THE OX.

O., Humerus; Sp., radius; E., ulna; Hw., carpal bones; M., metacarpal bones; 1, 2, 3, phalangeal joints (joints 3 being surrounded by hoofs, marked in black).

i. The Ox and his Enemies.

1. A traveller who came across a number of wild cattle in the valley of the Hoangho (China) reports that they were hunted with great difficulty, being very "cautious and of keen senses." They observed the sportsman before he even got within range. The keenness of their *smell* is indicated sufficiently by their widely-open, constantly-moistened nostrils (compare with dog). The conical *ears* are very movable, and their openings are pointed in the direction whence a sound proceeds (compare with hare).

The *eyes* of our domestic cattle are large and dull, indicating feeble sight. Wild cattle, on the other hand, have, as a rule, bright, brilliant eyes, evidently endowed with such visual powers as are required for a life in a state of nature.

2. The same traveller further tells us of the wild cattle of the Hoangho that they are "as *light-footed* as antelopes" (which see).

(*a*) That the ox is fleet of foot would appear from the fact that it is a digitigrade animal (see wolf), walking, moreover, only on the *tips* of two toes, the third and fourth. The metacarpal and metatarsal bones of these digits are united to form strong tubular bones, which act as firm pillars for the heavy body, and give the necessary length for a running

Digitized by Google

animal. The second and fifth digits are rudimentary, and do not reach the ground.

(*b*) The toes are invested in stout hoofs, enabling the animal to step firmly and plant itself securely against the inequalities of the surface. Though the domesticated ox cannot, by a long way, attain to the speed of the antelope, it can nevertheless, on occasion, run with considerable velocity, as anyone can tell who has ever seen a wild bull rushing over the fields. Nor is great speed of locomotion an indispensable condition of the animal's life, since it is sufficiently protected by—

3. *Its large size and great strength*, and by—

4. The possession of special organs of defence, viz., the *horns*. These are hollow, and form sheaths or covers for large bony excrescences developed from the frontal bones. The presence of these organs conditions the *great breadth and height of the forehead*. The *cranial bones are*

SKULL OF THE OX. (One-fifteenth natural size.)
The right horn has been removed from its bony core and drawn below it.

of unusual thickness, and capable of enduring the hardest blows. The force employed in the use of the horns as thrusting or butting weapons is supplied in the powerful musculature of the nape of the neck. Through the presence of these muscles and a loose-hanging cutaneous fold, the dewlap, the neck appears shorter than it really is. The spinous processes of the cervical vertebræ, and especially of the first dorsal vertebra, are very long, and furnish surfaces of attachment for the muscles. The strength of the ox lies chiefly in the neck. Accordingly, when made to draw a cart or the plough, the yoke is attached to the animal's forehead.

5. Wild or semi-savage oxen live in *herds*, which renders them better able to defend themselves than if they lived in a solitary state.

Digitized by Google

6. Among the smallest and, at the same time, fiercest enemies of the ox must be placed the flies. (See gad-fly, the *Hypoderma bovis*, and the African tsetse.) These pests it endeavours to drive away by lashing its *tail, convulsively twitching its skin*, or flicking them off its eyes with its external ears.

ii. The Ox a Herbivorous Animal.

1. It is a well-known fact that a piece of meat furnishes a more lasting nourishment than an equivalent amount of bread or any other vegetable product (*e.g.*, fruit or vegetables). Vegetable substances are therefore less nutritious than animal products (flesh, milk, blood, etc.). The ox, accordingly, having to support a body of large size, is obliged to take in *large quantities of food*.

(*a*) An animal of the size of an ox would not be able to satisfy its hunger if it cut off the blades of grass singly, one by one (or in small fragments, like rodents). It therefore pulls up its food in *bunches*. In this task it is greatly assisted by the tongue, which is very long, and, being protruded laterally from the mouth, grasps the bundle and conveys it to the teeth. The tongue, moreover, is very rough, and therefore able to obtain a firmer hold of the grass.

Anterior Portion of the Lower Jaw of the Ox.

(*b*) For tearing off the bunch a *long row of incisors* is necessary. These teeth, accordingly, are broad and numerous, six in number, and confined to the lower jaw. The lower canine teeth also have the same form as the incisors. By these teeth the bunch of fodder is pressed against the edge of the upper jaw, which is toothless and cartilaginous. The tufts of grass are detached by an upward push of the head. The incisors are very long and large, and directed obliquely forwards, so that the animal is able to cut off quite short grass; but in this case no assistance is rendered by the tongue.

(*c*) A great part of the day is spent by the ox in the act of feeding. While thus engaged it cannot, like carnivorous animals, lie down or stand still, but must continue to move along slowly. To this end it is furnished with *strong legs and feet, which terminate in stout hoofs* (compare with cat). Wild cattle, moreover, in order to find fresh pastures, are often obliged to undertake long migrations.

(*d*) The *strong musculature of the neck* enables the animal while feeding to keep its head depressed for the space of hours.

Digitized by Google

(*e*) The large quantity of food taken in calls into requisition a *large stomach* for its reception and digestion, as well as of—

(*f*) A *long intestine*—it is about twenty-two times as long as the body—offering a large surface of absorption for the nutritious particles of the food, which are only sparingly scattered throughout the whole digestive mass (chyme). (Compare, on the contrary, the carnivora.)

2. The nutritious elements of vegetable substances (starch, sugar, albumin, etc.) are enclosed within hard coats of cellulose, which are not dissolved by the digestive juices. In order that their enclosed contents may be digested, these cellulose envelopes must be destroyed, and to effect this the vegetable materials taken in as food require to be crushed and ground up *as finely as possible*. (Compare, on the other hand, the dog, which swallows a piece of meat thrown to it without previously chewing it at all.) The grinding up of the food is effected by—

(*a*) A *lateral grinding movement* of the lower jaw. To this end the articular heads, or condyles, of the lower jaw have the form of transversely-placed rollers, turning in corresponding sockets of the temporal bones.

ROW OF MOLARS IN THE UPPER JAW OF THE OX.

(*b*) For the same purpose the two rows of *molars* in the upper jaw are placed *farther apart* than those of the *lower jaw*.

(*c*) The crowns of the molars are broad, and their surfaces are raised into blunt tubercles (compare with a millstone).

(*d*) These tubercles have the form of *crescent-shaped folds of enamel* (*selenodont*), arranged in the longitudinal direction of the jaw, the convexities of the crescents being turned inwards in the teeth of the upper, and outwards in those of the lower, jaw (compare with rodents).

(*e*) In order that the food may be thoroughly ground up, a large grinding surface is necessary. Accordingly, the molars are both large and numerous, six on each side above and below.

(*f*) For the presence of such a number of large teeth large jaws are required, which explains the *elongated head* of the ox.

(*g*) There is a large gap or diastema between the incisor-like canines and the molars in the lower jaws.

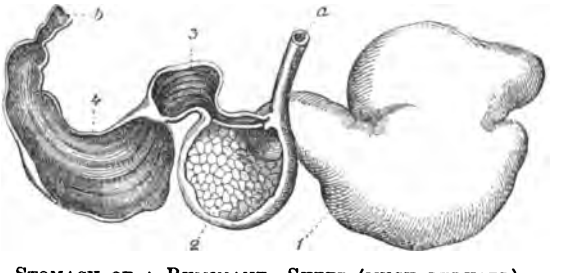
(Compare the ox with the cat also in regard to incisors and molars, length of jaws, equipment of feet with hoofs and claws respectively.)

(*h*) The longer a man moves, and the more energetic his movements, the more food is he obliged to take, in order to replace used-up force; the longer he remains at rest, the less force is used up, and consequently

Digitized by Google

the less food required to replace it. The same law applies equally to animals (compare with bat and mole). Applying this principle to the ox, it is easily seen that if this animal were at once to grind up its food, while in the act of feeding, to the necessary fineness, it would be obliged to stand or slowly walk about on the pastures for an even longer time than it actually does. In consequence, however, of the *division of the stomach into four compartments and the act of rumination*, the animal is able to carry on the greater part of the act of mastication while at *rest*. It is evident that in this manner *much force is saved*, and the animal is consequently able to do with *less food* than it otherwise would. (For the importance of the act of rumination in the case of animals living in a wild state, or those which have reverted to that condition, compare the deer, Section C.)

The food which has been torn off and only partially masticated passes through the œsophagus into the first great division of the stomach, the *paunch* or *rumen*, which forms, in fact, a large receptacle or reservoir; thence it passes into the second compartment, called, from the fact of its inner mucous surface being raised into a great number of reticular folds, the *reticulum*, or *honeycomb stomach*. After taking in a sufficient quantity of food, the animal lies down, and engages in the business of rumination, which proceeds as follows: By a convulsive action of the muscles of the œsophagus, resembling a hiccough, the food, which has been well sodden in the stomach, is forced back from the reticulum into the mouth in the form of small pellets or boluses. It is now, for a second time, carefully masticated, and by the abundant secretion of saliva (from numerous large salivary glands) converted into a pulpy or pap-like mass, and swallowed a second time. This time it is conveyed into the third division of the stomach, the *psalterium* (called *manyplies* by butchers), so called from the fact that its inner mucous membrane is produced into a number of folds, resembling the upstanding leaves of an open book. The reason why the food this time passes into the third, and not back into the two first divisions of the stomach is that the œsophagus, where it opens into the stomach, is



STOMACH OF A RUMINANT—SHEEP (MUCH REDUCED).
a, Lower section of the œsophagus; *b*, commencement of small intestine; 1, paunch; 2, reticulum, above which the gutter passing on to (3) the psalterium; 4, abomasum. (2, 3 and 4 are laid open.)

Digitized by Google

prolonged, in the shape of a gutter or half-tube, into the third compartment. When the edges of this gutter stand apart, the food falls into the paunch; when, however, they are applied against each other, thus converting the gutter into a perfect tube, the ruminated food is conveyed into the psalterium. Digestion proper does not take place until the food enters the last compartment, the *abomasum*, or *rennet stomach* (see p. 8). It takes the latter of its names from a peculiar secretion of its mucous membrane, the *rennet*, which in the stomach of the young calf causes the milk of the mother to curdle.

C. The Ox as a Domestic Animal.

We have seen how rumination implies a saving of force, and consequently of food. This capacity is not only of great value to the animal, but also to man. *The ox, in fact, in virtue of this ruminating capacity, from a certain amount of food unfit for human consumption (grass, flowers of the field, etc.), produces a larger quantity of food suitable for human nourishment (meat, fat, milk) than it otherwise would, and, if supplied with an abundance of fodder, is more rapidly and easily fattened.*

All mammals produce milk only as a nourishment for their young. When these are capable of finding their own food, the parents refuse them further access to the teat, and the nourishing spring dries up. With his domestic cattle, however (cow, goat, reindeer, camel, and in some parts even horses), man does not allow matters to proceed so far. He assumes to himself the part played by the young, for by *constant removal of the milk (milking) he stimulates the milk-glands so that they continue to secrete for a longer period.* The cow, having but one or at most two calves at a time, is provided with only four teats (compare, on the contrary, the large number of teats in the pig, dog, cat, etc., in relation to the large number of their young). The value of cow's milk to man (as a source of butter and cheese), and the further uses of this animal by reason of its flesh, fat, hide, hair, horns, and bodily strength, are too well known to need further discussion.

D. The Nearest Relatives of the Ox.

The representative of the ox in India and East Africa is the **Zebu**, or **Humped Ox**, of which there are several breeds or varieties. It derives its second name from a hump of fat on the front part of the back (see camel). For the performance of labours of various kinds, and for riding, and also on account of its flesh and milk, it is of the highest importance.

In the **Buffaloes** (*Bubalus*) the horns are placed on the skull not far from the eyes, and are very thick at the roots. Among these we must

Digitized by Google

class the **Common** or **Asiatic Buffalo** (*B. buffelus*), which is said still to occur in the wild state in the East Indies. It is of the highest importance as a draught animal in India, Mesopotamia, Syria, Egypt, and the South of Europe. Being fond of swampy districts, it renders useful services to man, more especially in the rice culture. The **Cape Buffalo** (*B. caffer*), a very vicious animal, inhabits in large herds the swampy districts of South and Central Africa. Its powerful horns are used a good deal with us for the manufacture of combs and similar articles.

In the **Bisons** (*Bison*) the spinous processes of the last cervical and first dorsal vertebræ are much longer than in the ox. The front part of the back, which is covered by a mane, appears, accordingly, disproportionately high. The powerful head bears short horns. The **European Bison** (*B. europæus*) is already extinct, while the **Buffalo**, or **American Bison** (*B. americanus*), has also very nearly disappeared. But a few years ago innumerable herds used to inhabit the vast plains of North America, forming the principal object of the chase to the native Indians. But thousands of these gigantic animals were shot down by European settlers, sometimes for the sake of their skins or tongues, but in many cases from a mere love of slaughter. A last remnant has fortunately found a safe asylum in the Yellowstone Park.

Other Horned Ruminants.

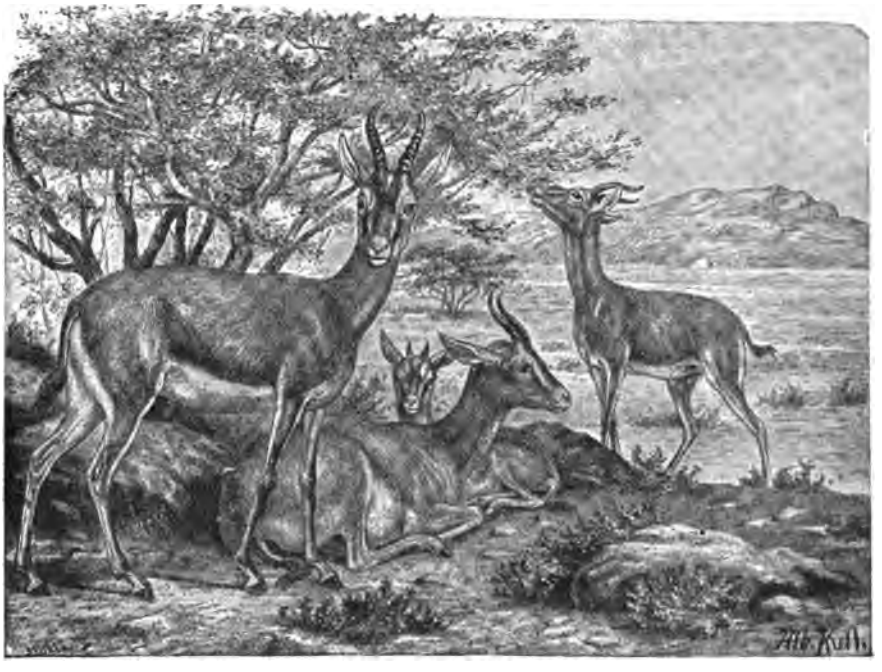
Next to the ox, the **Sheep** (*Ovis aries*) and the **Goat** (*Capra hircus*) are among the most important domestic ruminants. The form and structure of their body (describe it) and their manifold uses are generally known. The goat has aptly been named "the poor man's cow." This animal, however, is one of the most destructive foes of the forest, inasmuch as it is fond of gnawing the stems of trees and eating up the young plants and shoots of forest trees. The deforestation and resulting barrenness of the mountains and dryness of the climate of the countries bordering on the Mediterranean must be ascribed in great measure to the agency of this animal.

Of the many varieties of the goat and sheep, we shall only mention in the case of the former the small, inconspicuous **Heath Sheep** of the Lüneburg Heath, and the **Merino Sheep** of the table-lands of Spain, which furnishes the finest wool; and in the case of the latter species the **Angora Goat** of Asia Minor, the fine, silk-like hair of which is employed in the finest textile fabrics. Like the **Ibex** (*C. ibex*), a near relative of the goat, the ancestors of both animals were inhabitants of rocky districts. This is sufficiently indicated by their extraordinary adeptness in climbing.

The **Antelopes**, which inhabit by preference the steppes and deserts

Digitized by Google

of Africa, form a group rich in species and varieties. The best-known African antelope is the **Gazelle** (*Antilope dorcas*), an inhabitant of the desert, about the size and shape of a roe, but much more graceful. Its coat is of the colour of the desert, and even escapes the keen falcon eye of the native, who frequently is unable to distinguish the animal from stones or desert rocks. The slender body and the thin but strong legs, with their small hoofs, enable the animal to run with the speed of the wind, to find sufficient food in the barren districts of its home (North Africa, Arabia, and Syria), and to escape from its numerous fleet-footed



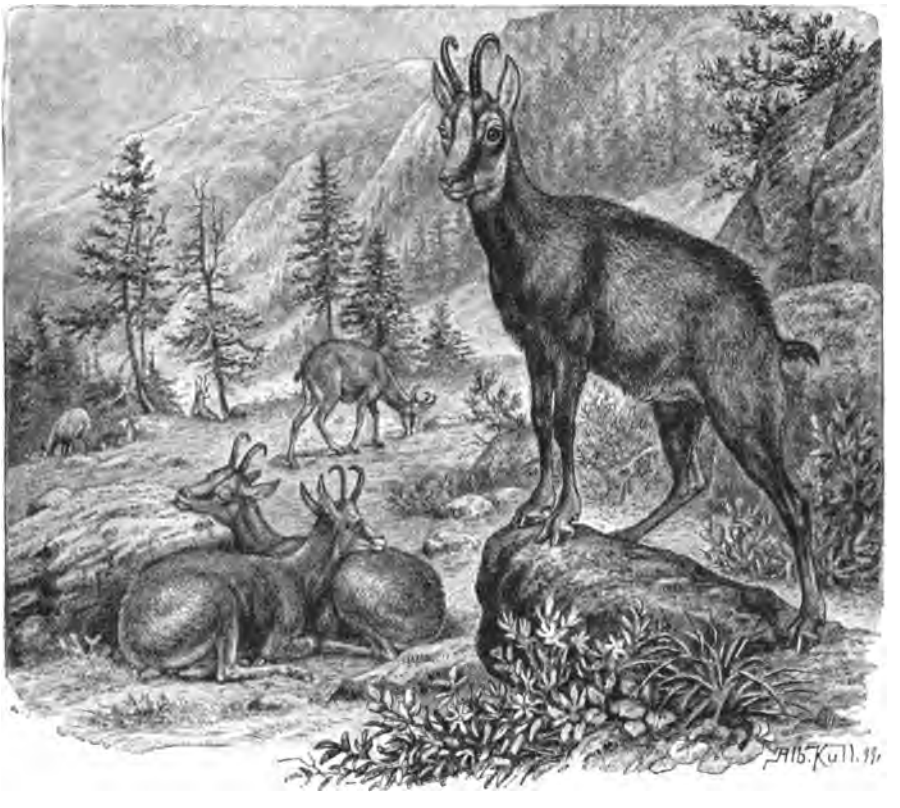
GAZELLE. (One-fifteenth natural size.)

enemies (leopards, jackals, greyhounds, etc.). Both the male and female have horns bent in the shape of a lyre.

The only European antelope is the **Chamois** (*Rupicapra tragus*). It inhabits the Alps, Pyrenees, Abruzzi, Carpathians, the highlands of the Balkan Peninsula, and the Caucasus, and is therefore a true inhabitant of the mountains, which it ascends up to the limit of plant life. After a herd has settled down at a spot offering a view around, some few of the animals are always observed to remain standing upright and on the look-out. As soon as they notice anything suspicious, they utter a

Digitized by Google

short whistle, whereupon the whole herd takes to flight. The chamois is a skilled and fearless climber and a bold and sure jumper, scaling rocks which are inaccessible to man as if carried on wings. Ledges no broader than a man's hand are a sufficient foothold. It can spring up vertical walls of rock as high as 13 feet with the same ease as it leaps across chasms 24 feet in breadth. When hard pressed it will climb down the steepest cliffs by planting its legs far forwards, and does not



CHAMOIS. (One-sixteenth natural size.)

shrink from a leap over a precipice. For the execution of such wonderful feats the animal is adapted by its short, thick-set body, its long, strong legs, and its thick hoofs, which can be spread widely apart, and are also hollow and provided with sharp cutting edges. The horns, which are curved backwards and very pointed, furnish both male and female with useful weapons of defence. The brown and thin summer coat gives place in the autumn to a winter growth of lighter, thicker, longer hair. The

Digitized by Google

chase of this bold child of the mountains requires a man's whole strength, courage, and endurance (see Schiller's poem "The Alpine Hunter").

Family 2: Antlered Ruminants or Deer (Cervina).

The Roe Deer (*Cervus capreolus*).

(Height at shoulders about 3½ feet; length of body 2½ feet.)

A. Distribution.

This handsome animal, rightly called the ornament of our forests, is found throughout the whole of Europe and in Western and Northern Asia. It rarely occurs beyond 58 degrees north latitude, the winter of Northern countries being too long and too severe (dearth of food).

B. Enemies.

Like all other herbivorous animals, the roe also forms the prey of the larger carnivores. The bear, wolf, lynx, and wild cat are its constant pursuers. In Britain and Western Europe its chief enemy is man, though many young does fall victims to the fox, and even the bloodthirsty marten and weasel (see also gadflies, etc.). Against these various animals the roe is protected by—

1. Its *habitat.* The forest, densely overgrown with underwood, in itself affords a certain amount of shelter. As the animal reposes, chewing the cud, under a bush among dry leaves, it is only with difficulty discernible, owing to the *colour of its skin*, which resembles that of the forest soil. The underside of the body is lighter than the back, which is of a rusty brown colour. The tail is short, and is covered with white hair. In the young, which are most exposed to danger, the skin is dappled with light spots, giving them a close resemblance to the forest soil, with its darker and lighter dry leaves, and rendering them still more difficult of observation than the old animals, which are fleeter of foot and better equipped with means of defence. With the approach of the colder season, the coat becomes lighter coloured and thicker (explain the importance of these changes). The *strength and hardness of the longer hairs* is also in relation with the animal's habitat among the underwood (compare with wild boar).

2. The *sense of smell*, of the greatest importance to a forest animal, is in the case of the roe so keen that the animal can scent its hunter at a distance of 600 paces, long before the enemy can approach within dangerous proximity. This acute smell is, in fact, indicated by the wide, open nostrils, which are kept constantly moist (compare with

Digitized by Google

wolf and dog). The *sense of hearing* is extremely acute; the least suspicious sound attracts the animal's attention. The long, conical *ears* are very movable, and the animal turns their openings in the direction whence the sound proceeds. During flight they are laid backwards, as in all other herbivora (compare with hare). The *eyes* are large and bright, pointing to the possession of sharp sight. In the inner angle of the eye these animals have a pit—the "lachrymal pit," which lodges a peculiar gland secreting a waxy substance resembling ear-wax.

3. No sooner has the animal observed its enemy than it takes to speedy *flight*. It literally seems to fly along, displaying wonderful power and skill in running and leaping, for which the structure of its body and limbs renders it specially adapted:

(*a*) The *body is slender*, and cuts through the air with ease, especially since, in running at a great speed, the animal stretches the head forwards (compare with wolf and dog).

(*b*) The *legs* are graceful, slender, and long. The hind-legs, being longer than the fore, are bent when the animal stands still, so that the body remains horizontal.

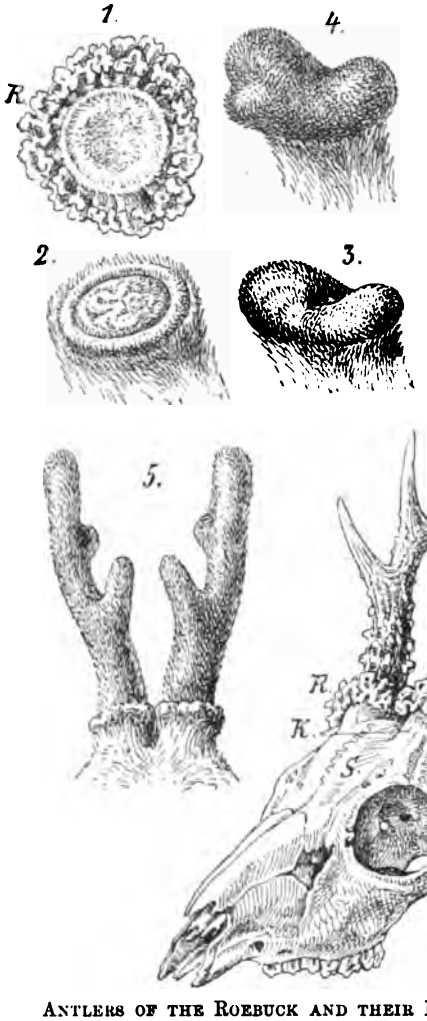
The legs are constructed on the same plan as those of the ox, but the second and fifth digits are less reduced, and the hoofs are much more pointed, harder, and sharp-edged. By means of its hard hoofs the female, which has from one to three young annually, can deal out severe blows in defence of its offspring.

4. The male possesses in its *antlers* formidable weapons against other males of its species, as well as against enemies, being able to inflict serious wounds even on man. The fights with the members of its own species take place in July and August, its object being the possession of the females (does), with whom it lives in a state of polygamy. These fights are sometimes conducted with such passion that one of the combatants is left dead on the field. Let us now inquire into the origin of these peculiar weapons.

Towards the end of the winter of the animal's first year of life two bony processes, which persist during the whole life of the animal, and are surrounded with hairy skin, are developed upon the frontal bone. In the following spring two spear-shaped antlers are developed from the tips of the bony protuberances, and are covered with a velvety skin (the velvet). The antlers are at first soft, and bleed on the least injury, which the animal, accordingly, takes the utmost care to avoid. By the subsequent deposition of calcium carbonates and phosphates, they gradually harden into true, massive bones. The circulation of blood then ceases, the velvet dries up, and is "peeled off" by rubbing against the stems and branches of trees. The animal is now known as

Digitized by Google

a "brocket." In the following autumn the antlers, the lower, disc-like ends of which are known as "burrs," become loose and drop off. A few days afterwards the beginnings of a new pair become visible, these being developed in exactly the same manner as the "beams" of the first year, but having in addition a lateral basal branch, or brow tyne, the animal being now termed a "forker" (two-year-old). In the next change of antlers each of the beams bears two branches, or prongs, and the "forker" has thus developed into a six-point buck. By further additions of lateral branches, as many as eight or ten prongs are developed in exceptional cases.



ANTLERS OF THE ROEBUCK AND THEIR DEVELOPMENT.

1. Lower end of the shed antler, with the burr, R.
2. Upper end of a pedicle, shortly after shedding of the antler. A ring-shaped swelling shows the commencement of the growth of the new antler; this swelling after two weeks is larger, as at 3, and 4 (a week later) shows the young antler growing out.
5. Complete antler of a six-point stag in the velvet.
6. Hardened and peeled antlers of a six-point buck; K pedicles, R burr.

5. As compared with a carnivorous animal (*e.g.*, the wild cat), the roe, on the whole, must be considered a somewhat defenceless animal. During the time the antlers are being formed, even the male shyly avoids every danger, nor would the female venture to defend herself against the fox if she were not impelled by an all-overpowering mother's love for her young. As a rule, the buck seeks salvation in speedy flight.

Digitized by Google

(Why can it not be, like a carnivore, provided with sharp claws or cutting teeth? Compare it in regard to food.) This lack of the means of defence explains—

(*a*) The *timidity* of the animal.

(*b*) Why it leaves the *protection of the forest only in the evening*, in order to seek the juicy crops of the field. On such occasions the herd proceeds cautiously, constantly on the scent and the alert, the male leading, and the females and young following after. The feed accomplished, the herd re-enters the darkness of the forest in the reverse order.

C. The Roe as a Ruminant.

Apart from the food-plants of cultivated fields, the buck consumes the leaves of all sorts of trees, the buds of pines and firs, grasses, acorns, beech-nuts, etc.

As it feeds in the same manner as the ox, the organs of digestion (teeth, stomach, intestine) are arranged on exactly the same plan (see under "Ox"). Rumination, however, is to the roe (as, indeed, in the case of all ruminants living in a wild state) of even greater importance than to the latter animal. If so defenceless an animal were at once to masticate to its requisite fineness the large quantity of vegetable substances it requires (see ox), it would employ a very considerable time in this business, and thus *also be exposed unprotected for a long time to its numerous foes*. But being endowed with the ruminating capacity, it in a very brief space obtains all the food it requires, and then performs the actual business of mastication in a safe retreat.

D. The Roe in Relation to Man.

The farmer, whose carefully planted crops it pilfers, naturally has nothing good to say of this handsome animal; nor is it a friend of the forester, many of whose young trees it damages by rubbing off the bark with its antlers, and biting off buds and young shoots. This damage becomes still more serious during hard, snowy winters, when it is compelled to appease the pangs of hunger by gnawing off the bark of trees. Nor is the damage it inflicts made good by the value of its flesh, skin, and antlers.

Other Species of Deer.

The Red Deer (*Cervus elaphus*).—This handsome animal has deservedly earned the title of King of the Forest, by reason of its size and noble shape, its strength and speed, its magnificent antlers,

Digitized by Google

and the fine mane which adorns the neck of the male. It avoids forests with underwood, where its huge, many-pronged antlers, the weight of which requires a short and powerful neck (bull-necked; see ox), would impede its movements. It therefore prefers highland forests. The stag sheds his antlers in February. Its mode of life resembles that of the roe deer, but it inflicts even greater damage on the farmer and forester than the former species.

The Fallow Deer (*Dama vulgaris*) originates from the countries bordering the Mediterranean. In this country it is kept as an ornament to parks. The male carries palmate antlers.

The Elk (*Alces palmatus*).—This animal was formerly abundant in Germany, but at the present day a few head only are preserved in the forest of Ibenhost, near Tilsit. In Scandinavia, the northern parts of Russia, Asia, and North America, it is still met in the wild state. It is a powerful animal, with long legs, reaching about the size of a horse. It inhabits marshy forests. Its hoofs can be spread wide apart, and are united by an extensile skin, and together with the posterior toes, which almost touch the ground (compare the wild boar), enable it to cross swamps which a man could not set foot on. The antlers are of very large size, and may weigh as much as 40 pounds; their surfaces are very broad (palmate). The neck is, accordingly, short (see head of elephant), so that the animal can hardly approach its mouth to the ground. Its food therefore consists of the leaves of young trees, shrubs, bark; but its favourite food is supplied by the willow. By means of its upper lip, which is elongated almost into a snout, it seizes whole bundles of leaves, and conveys them to its mouth. With its chisel-shaped incisors it detaches the bark until it can reach it with its upper lip, and then tears it off in large pieces from below upwards.

The **Reindeer** (*Rangifer tarandus*) is a true denizen of the North. The hair in the summer is dark coloured; with the approach of the colder season it is exchanged for a winter fur about 1½ inches thick, and of a dirty-gray colour, but little different from that of the snow. The hoofs are broad and deeply cleft, and can therefore be spread widely apart, whilst the posterior toes actually touch the ground (note the track in illustration opposite). By these means the animal is enabled to traverse inhospitable marshes, as well as the immense snow-plains of its home (compare with wild boar). Its chief food in the winter is the reindeer moss (*Cladonia rangiferina*), which in the North covers vast plains, and is also met with in German forests. To get at it the reindeer scrapes away the snow with its hoofs, and, according to some naturalists, with the additional help of its nose and antlers. The

Digitized by Google

lowermost tyne (so-called brow tyne) of either the right or left antler—the female also bears antlers—is always larger than the one opposite, and bent in such a manner as to stand vertically over the nose, forming with it a kind of snow-plough, as it were.* The inhabitants of the North have domesticated the reindeer, and keep it in large herds. On its welfare depends that of the country; but when decimated either by foot and mouth disease or the ravages of beasts of prey (especially wolves), poverty, misery, and even famine, invade the huts of the nomadic inhabitants. Its disappearance (or that of the reindeer moss) would mean the cessation of all human life in those latitudes. For the reindeer is all and everything to the native of the North: it carries

REINDEER. (The animal in the foreground one-twenty-fifth natural size).

him in his light sledges over the endless snow-wastes; its skin provides him with tent-coverings, clothes, and leather; its flesh, milk, and blood supply him with his most important articles of food; from its tendons he manufactures thread for sewing, from the intestines ropes for binding, from the bones and antlers spears for fishing, fishing-rods, and other utensils; the tongue and the still warm marrow of the bones are considered delicacies, and even the contents of the intestines are utilized as vegetables.

* In the animal depicted in the foreground of our illustration, it is the left brow tyne which thus enlarged; the right is so short that it is completely hidden by the left antler.

Digitized by Google

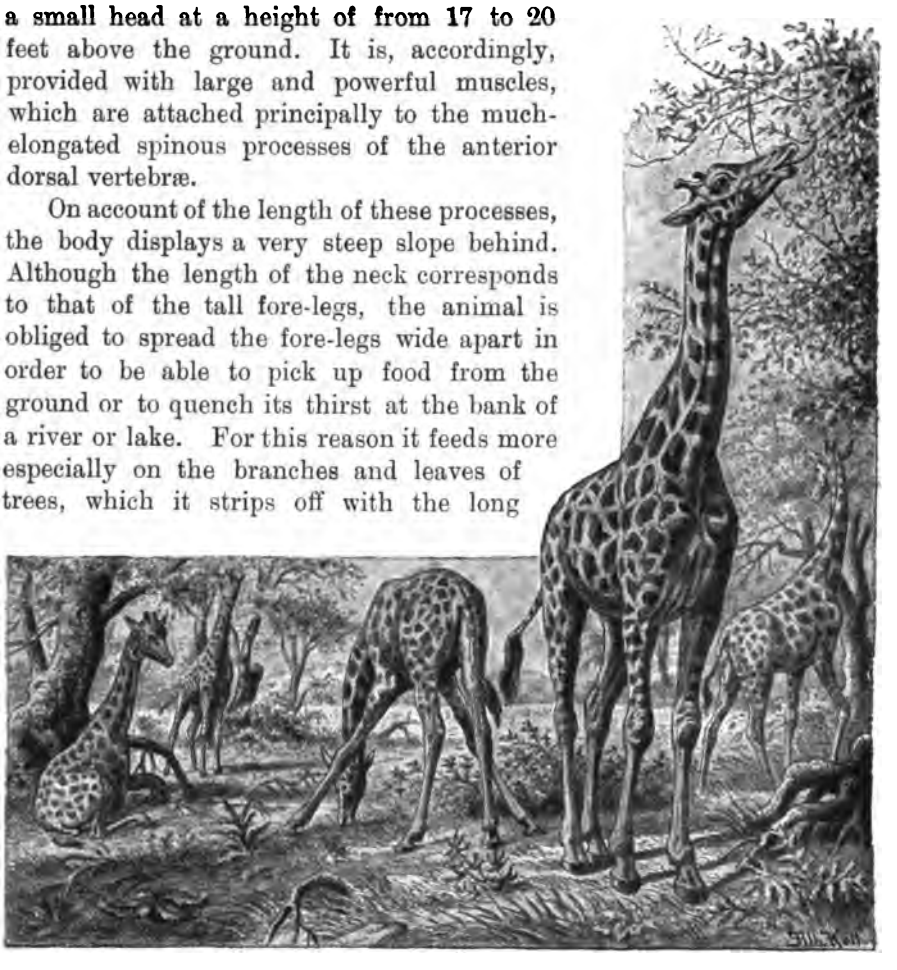
Family 3: Giraffes (Devexa).

The Giraffe (*Camelopardalis giraffa*).

(Height at shoulders about 10 feet.)

The home of this peculiar animal is on the plains of Central and Southern Africa. The neck is of extraordinary length, and supports a small head at a height of from 17 to 20 feet above the ground. It is, accordingly, provided with large and powerful muscles, which are attached principally to the much-elongated spinous processes of the anterior dorsal vertebræ.

On account of the length of these processes, the body displays a very steep slope behind. Although the length of the neck corresponds to that of the tall fore-legs, the animal is obliged to spread the fore-legs wide apart in order to be able to pick up food from the ground or to quench its thirst at the bank of a river or lake. For this reason it feeds more especially on the branches and leaves of trees, which it strips off with the long



GIRAFFES IN A MIMOSA GROVE.
(The animal standing erect in the foreground about one-sixtieth natural size.)

vermiform tongue. From its peculiar shape and colour (pale yellow, with numerous brown spots), one might suppose that the animal would

Digitized by Google

easily attract attention even from afar. This, however, as travellers tell us, is by no means the case. Standing among the trunks of the mimosa-trees, which furnish its favourite food, the giraffe cannot, even at a short distance, be distinguished by the sharp-sighted natives from a dead, lichen-covered tree-trunk. Out on the open plains the animal seeks salvation in speedy flight (long legs, elegant hoofs). When attacked, however, it is able to defend itself effectually by means of its frontal horns (bony protuberances covered by the skin); for, by swinging its long neck, it can execute forcible blows with its head.

Family 4: Camels (Camelidæ).

The One-Humped Camel, or Dromedary (*Camelus dromedarius*).

(Height at shoulders 6½ to 7¼ feet.)

A. Habitat and Importance.

The dromedary is met with from the barren regions in the North-West of India, throughout the whole of Persia, in the Caucasus region, in Mesopotamia, Asia Minor, Palestine, Arabia, and over all North Africa. Recently it has been introduced into dry districts in South Europe, Australia, and North America. From times immemorial (Abraham) it has been an indispensable domesticated animal in Eastern countries. Indeed, the existence of whole populations depends on this animal. By its agency barren steppes, waterless and devoid of plant life, are rendered habitable (prove this from the subjoined remarks on the structure of the animal); for it provides its master with all the necessaries of life (fat, flesh, milk; even the dung is used as fuel, in place of wood). By its aid alone is he able to traverse the inhospitable tracts of desert sand and rock, and to convey his merchandise from one shore of the sandy ocean to the other. With truth, therefore, has the Arab called this animal—

B. The "Ship of the Desert."

Let us picture it in this light. Let us imagine a caravan wending its way through the desert, and consider how the camel, by its *bodily structure*, is able to render such important services to man.

1. Heavily loaded, the camels pass on their way; for, being animals of *large size*, and consequently of *great strength*, they are capable of bearing heavy burdens (up to 800 pounds; on long desert journeys the load is only about 300 pounds).

2. For miles and miles the ground is covered with sand, cutting

Digitized by Google

sharply into the feet, and raised in the course of the day to furnace-heat. A horse would sink in it, and severely injure his feet. The camel, on the other hand, in spite of its own weight and the load it has to bear, strides lightly across it; for it does not, like other ruminants and the horse, touch the ground merely with its hoofs, but with *broad, callous soles or pads* of horny integument beneath the terminal joints of the two middle toes, which alone are present. These soles, in front of which are the small hoofs or nails, form broad surfaces of support, which prevent the animal from sinking in the soft soil, and thus also protect the hairy portions of the legs from injury. The soles, being very *hard*, are insensible both to the sharpness and heat of the sand, and being, moreover, as *elastic as springs*, render the walk of the animal light in spite of the apparent clumsiness of its feet.

3. The fiery globe of the sun is setting on the unclouded horizon. The time of repose approaches for the caravan. The camels sink down to be relieved of their burdens. The *callous pads* with which they are furnished on the chest and at the joints of the legs serve them while resting as protecting cushions against the sharp, hot sand.

4. As the camel lies on the ground with outstretched neck and head, we can clearly see that the pale-yellow or brown colour of its skin is scarcely distinguishable from the soil. At a distance, a camel at rest is said to be indistinguishable from a block of stone. (As in the case of all domestic animals—see cat—examples are found here also which do not possess this protective colouring.)

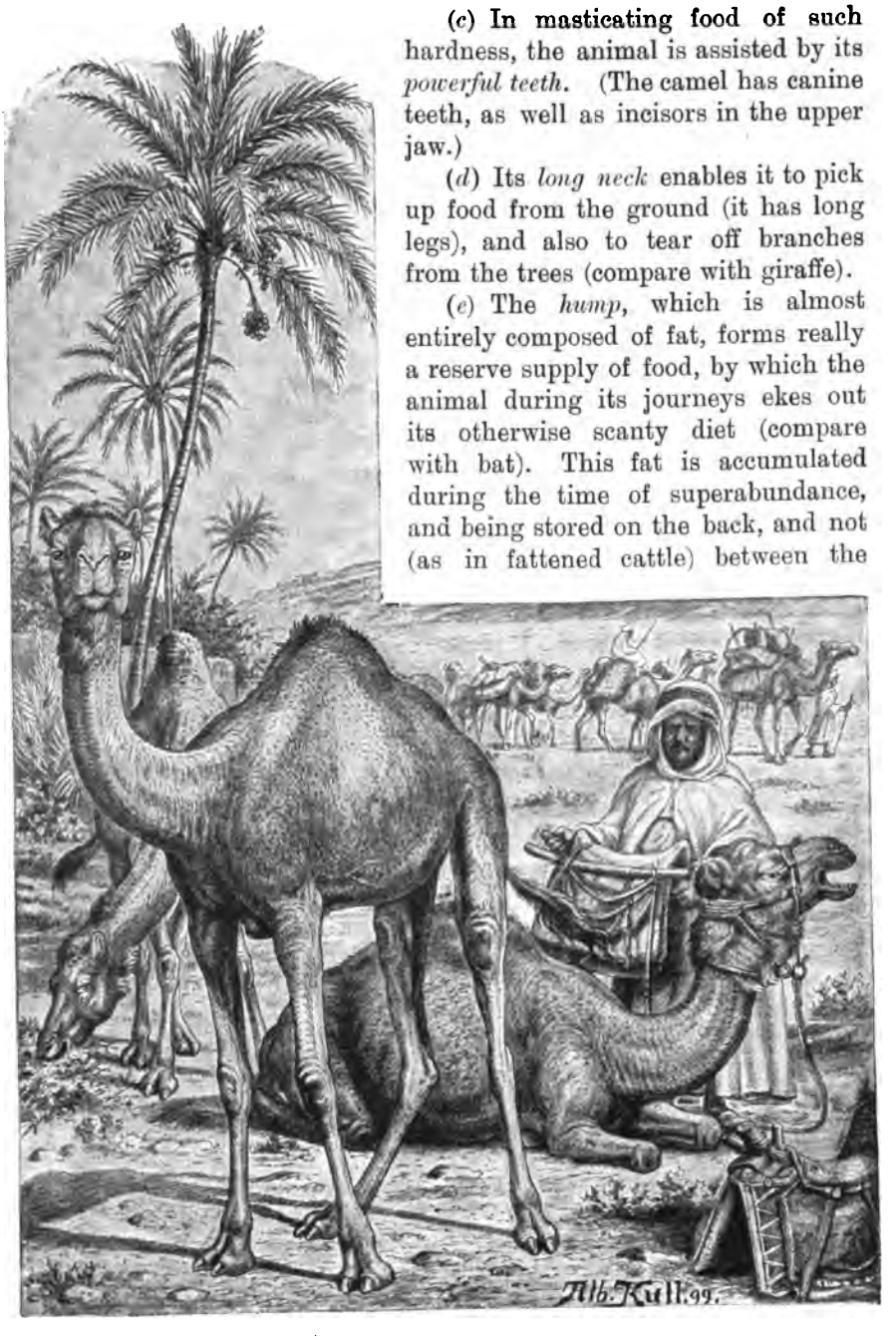
5. The travellers now open the sacks of fodder; but the animal's wants are few and *easily satisfied;* a few handfuls of grain or beans constitute the whole day's provisions. What it needs beyond this for subsistence it has to seek for itself. (Why cannot the travellers take large stores of provisions with them?)

6. Here and there in the desert a bundle of tough, sharp-cutting grass sprouts up from the sandy soil, or a few shrubs, weeds, or trees prickly with thorns are to be seen. No other domestic animal could feed on these (why not?), but the camel is provided—

(*a*) With *lips insensible to pain, and movable*, with which it breaks off the thorniest branches and plucks the sharpest grasses, afterwards crushing them up in—

(*b*) Its *hard-skinned mouth*. From the report of an old and experienced traveller in the desert we may conceive some notion of the insensibility of the animal's lips, palate, and tongue. He says: "I once trod on a thorn which penetrated the sole of my boot, the great toe, and even the upper leather; and it is thorns like this which the camel chews up in its mouth with the utmost indifference."

Digitized by Google



(*c*) **In masticating food of such** hardness, the animal is assisted by its *powerful teeth*. (The camel has canine teeth, as well as incisors in the upper jaw.)

(*d*) Its *long neck* enables it to pick up food from the ground (it has long legs), and also to tear off branches from the trees (compare with giraffe).

(*e*) The *hump*, which is almost entirely composed of fat, forms really a reserve supply of food, by which the animal during its journeys ekes out its otherwise scanty diet (compare with bat). This fat is accumulated during the time of superabundance, and being stored on the back, and not (as in fattened cattle) between the

Digitized by Google

muscles or (as in the pig) beneath the skin, does not impede the animal's movements.

(*f*) Want of water is in itself sufficient to prevent any of our domestic animals from crossing a large desert. The camel, on the other hand, can exist without water for several days, even in the greatest heat, and even *for weeks* if there is a fair supply of juicy plants at hand. To provide against dearth of water, the animal, when it reaches a drinking-place, takes in a great quantity at once as a reserve supply, a portion of this water being stored within *folds of the paunch, which can be closed* (and thus converted into cells), and used afterwards by degrees as the animal requires it.

7. Only a *rapid* animal is able to cross the desert, with its dearth of water and vegetable life. (Why?) Its *long, far-stretching legs* enable the camel to progress with great *speed*. It displays at the same time an *endurance* much beyond that of any horse. A pack-camel can perform about thirty miles a day, whilst a fleet-footed riding-camel can accomplish about three times that distance. On account of its long legs and short body, the camel moves the two legs of one side together. If it moved them alternately, like the majority of mammals, it would tread on its fore-feet with its hind-feet. In consequence of this peculiar gait, the body swings from side to side (*ship* of the desert).

8. The desert abounds in dangers. Its great height enables the camel to *survey* extensive surfaces, and to observe an enemy from a distance. By the help of its keen *scent* it can detect a spring some miles off, even if it is hidden beneath the sand. By means of its highly-developed *sense of touch*, it can discern the approach of the hot wind of the desert (the simoom of the Sahara) much sooner than the traveller. Redoubling its steps, it endeavours to reach a place of safety, and in many cases travellers have owed their lives solely to their camels.

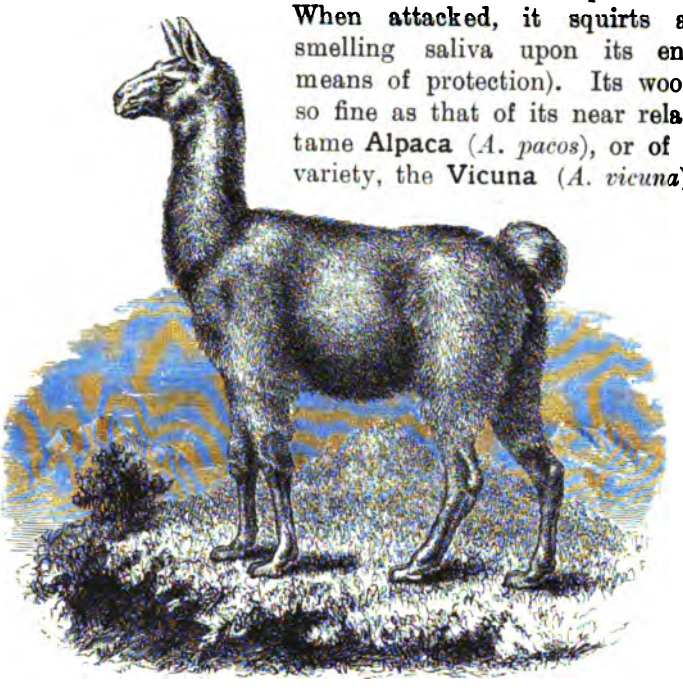
Related Species.

In the barren steppes of Central and Eastern Asia the place of the dromedary is filled by the **Two-Humped** or **Bactrian Camel** (*C. bactrianus*). Its denser coat enables it to defy the awful snowstorms of these districts. Saline plants being its favourite food, even the most inhospitable salt steppes are made habitable by its presence.

The **Llama** (*Auchenia lama*) is the most important domestic animal of the inhabitants of the South American Cordilleras. It only attains to about the size of a donkey, and is a true mountain animal; its toes are, accordingly, much more deeply cleft, the callous soles relatively smaller, but the hoofs larger and more pointed, than in the true camels (compare with chamois). Heavily loaded, the llamas, in long trains,

Digitized by Google

cross the highlands along paths scarcely passable by man. As the animal can always find food in abundance, no hump is developed. When attacked, it squirts an evil-smelling saliva upon its enemy (a means of protection). Its wool is not so fine as that of its near relative, the tame **Alpaca** (*A. pacos*), or of the wild variety, the **Vicuna** (*A. vicuna*). Both



LLAMA. (One twenty-fourth natural size.)

these animals live under the same conditions, and therefore closely resemble the llama.

ORDER X.: ODD-TOED UNGULATES (PERISSODACTYLA).

ANIMALS walking on an odd number of toes (five, three, or one), the third toe being always larger and stronger than the rest, the remaining toes either rudimentary or absent. Incisors are present in both jaws.

Family 1: Horses (Equidæ).

The Horse (*Equus caballus*).

A. Origin and Importance.

At the time of the mammoth (see p. 92) a wild species of horse (*E. c. fossilis*) existed in the whole of Europe, North Asia, and North

Digitized by Google

Africa. From numerous bone deposits, it appears that this animal was hunted and eaten as food. Naturalists have shown that in this animal we have the primitive parent of the horse of to-day. It is probable that the wild horse was first tamed on the vast steppes of Central Asia. There we still meet with nomadic tribes (Tartars, Kalmucks) who almost pass their lives on horseback (like the Huns of earlier times), and who subsist almost entirely on the flesh and milk of this animal. By its strength and speed, its indomitable courage, ready obedience, and affectionate nature, this noble animal has indeed become man's friend and indispensable helpmate in peace and war (furnish proofs of this statement), and even after death he turns to use all the parts of its body (flesh, skin, fat, hair, bones, and their applications). According to the special uses it was intended to serve, man has bred several varieties or races of the horse. Each country has its own special breeds. Thus, we have the "heavy" Danish, Belgian, English, and French (*Percheron*) breeds, which supply us with the best cart-horses. On the other hand, the Arab, Trakehner, and English thoroughbred carry their rider with the speed of the wind.

The size and colour (point out the different colours), too, of the horse have been largely determined by man's "taste" or "fancy." Take the difference, for instance, between a cart-horse and a pony, which often is not much more than 3 feet high at the shoulders. In fact, among horses, as among men, there are giants as well as dwarfs.

B. Body Structure.

To understand the structure and anatomy of the domestic horse, it is necessary (as in the case of the ox, which see) to consider horses which have reverted to the wild state. Large herds of these are found on the steppes of South-Eastern Russia (Tarpan), and on the immeasurable plains of South America (the mustangs of the pampas). When we consider that both the horse and the ox are true *inhabitants of the steppes*, many points of resemblance in their anatomy will become comprehensible.*

i. The Horse and its Enemies.

1. The so-called "wild" horse, like all other animals living in a state of nature, is accredited with the possession of very sharp *senses*. This specially applies to the *sense of hearing*. "Wild" horses which have been tamed, by movements of their conical ears, betray the perception of noises inaudible to their rider. By means of their *smell* (wide nostrils)—as we

* The following sections correspond with the similarly numbered or lettered sections under "Ox."

Digitized by Google

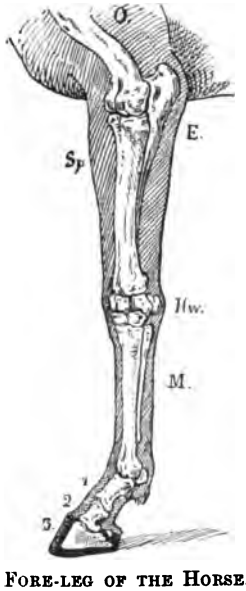
are informed by a traveller who has acquired an intimate knowledge of the horses of the pampas—these animals learn to recognise their rider, their harness, the shed in which they have been saddled, etc.; the same sense enables them to find their way back to their dwelling or pasture on dark nights or in dense fogs. Similar observations may be made in the case of our own domestic breeds.

2. As a *fast runner* the horse is a match for any other fleet-footed animal. The arrangements which specially adapt it for speedy locomotion are—

(*a*) Its *slender shape*. When running fast (racing), it stretches forward its head and neck, the latter being laterally compressed and adorned with a mane; the body thus assumes the shape of a pointed wedge, which easily cuts through the air. A good racer can accomplish over 900 yards per minute.

(*b*) The *legs*, which are long, light, and at the same time very powerful.

(*c*) It walks on the tip of only *one toe* (corresponding to the third in the human hand or foot). (Compare with wolf and ox.) Rudiments of the second and fourth metacarpals and metatarsals are present. The terminal joint of the third toe is very large, and is invested by a hoof like a shoe, thus forming a large surface of support. The animal does not walk upon the whole underside of the hoof, but only on the edge of it and on a ridge (the so-called "frog" of the veterinary) which passes from behind forwards along the concave sole. By means of this hard edge, which is well protected against wear, the animal can obtain a firm support against the inequalities of the surface. (This is specially noticeable in cart-horses.) The "frog," which consists of soft horn, acts as a pad which diminishes concussion when the hoofs strike the ground. The elasticity of the horse's gait is due to the angles at which nearly all the joints of the legs are set. The bend is greatest at the fetlock joints between the metacarpals and metatarsals and the digit. (Explain importance of this to the rider.) The hoofs of our horses are shod with iron, which protects them against the excessive wear to which they are subjected on the hard ground of roads, etc.



FORE-LEG OF THE HORSE.
O., Humerus; Sp., radius; E., ulna; Hw., carpal bones; M., metacarpal; 1, 2, 3, phalangeal joints (3 is invested like a shoe by the hoof, which is marked in black).

3 and 4. Its *size* and *strength* are in themselves a means of defence

Digitized by Google

to the horse; the large *incisors* (see below) and its stout hoofs are its principal weapons. With one blow of its fore-leg, which is further intensified by the weight of the body, it can kill a wolf, while it is well known what havoc it can make with a blow of the hind-legs.

(Its speed, size and strength, in addition to its stout hoofs, render the horse the most important of our draught animals. In the riding-horse the weight of the rider is borne on the firm, gently-curved backbone; in the draught animal the weight is allowed to act on the broad, powerful chest.)

5. Wild horses live in *herds*, whereby they are rendered still better able to defend themselves.

6. Against flies the horse defends itself by the same means as the ox, and also by kicking out with the hind-legs. The shortness of the *tail* is amply balanced by the length of its hairs. (Bring forward arguments for and against the custom of cutting off the hair of the tail.)

ii. The Food of Wild Horses consists principally of Grasses.

1. The horse, like the ox, requires *large quantities* of food.

(*a*) By means of *its lips, which are very movable*, it grasps the bundle of grass and pushes it into its mouth. (Observe the action of the lips when a horse is pulling hay from a waggon or taking a piece of bread from the hand.) The tongue is shorter than in the ox, and its surface without rugosities.

Skull of Horse (Male). (One-sixteenth natural size.)

(*b*) The *incisors* are broad, long, and directed obliquely forwards. There are six above and six below. In pulling up grass the horse jerks the head backwards. By the replacement of the incisors and the amount of wear the permanent set have undergone the age of the horse can be ascertained.

(*c*) The *legs* are powerful, and the *toes* invested in solid hoofs.

(*d*) The *muscles of the neck* are powerful, but less so than those of the ox, the head being hornless and not used for butting.

(*e*) The *stomach* is large, and (*f*) the *intestine* long, as in the ox.

2. The food of the horse, like that of the ox, must be *reduced to a finely divided state.*

Digitized by Google

(*a*) The movements of the jaws in mastication do not, however, proceed in so pronounced a transverse direction as in the ox.

(*b*) The distances between rows of *molars* above and below are nearly equal.

(*c*) and (*d*) The *enamel folds* of the molars do not run longitudinally, but are undulating.

(*e*) and (*f*) The *size* and *number* of the molars, and the shape of the *facial portion* of the skull, are as in the ox.

(*g*) The *canines* are small or entirely absent, especially in the female. The large *gap* between the incisors (or canines) and molar teeth forms a receptacle for the "bit." As a rule, only a slight pull or pressure is sufficient (so sensitive are the lips) to direct the animal or to make it start or stop.

(*h*) The horse does *not ruminate* like the ox and its congeners.

Other Equidæ.

The Ass (*E. asinus*).—Apart from its smaller size, the colour of the skin, length of the ears, and the presence of a hairy tuft on the tail, this animal completely resembles the horse. It is very modest in its requirements, being even satisfied with thistles. Its obstinacy has become proverbial. In the countries of the Mediterranean it is an indispensable helpmate, especially in garden culture. The **Mule** is a hybrid between the horse and the ass. It is of special importance in mountainous countries, combining the strength of the horse with the endurance and contentedness of the donkey. It strides securely along paths scarcely passable by man, and with terrible abysses lying below.

South and East Africa is the home of the striped and banded species of Equus, the best known of which is the **Zebra** (*E. zebra*). Its skin is white or light yellow, marked with black or brown transverse stripes. A striking colour pattern like this may at first sight appear a disadvantage to the animal by making its presence known to enemies at a distance. On the other hand, in virtue of this colour an animal which has become separated from the herd can descry its mates at a distance and quickly rejoin them; for these animals are so shy and cautious, and so fleet of foot, that even a lion or tiger can do nothing against a herd of them in the daytime. It is in the evening and on moonlight nights, when they go to drink, that they are in danger of falling a prey to the king of beasts lying in ambush for them. In the dim light, however, the darker and lighter stripes of the skin so run into each other as to make the animal appear gray and difficult to recognise even at a short distance: Thus their striking colour markings at once render them recognisable, and at the same time serve as a means of protection.

Digitized by Google

Family 2: Rhinoceroses (Nasicornia).

These "antediluvian" creatures are confined to the tropical swamps and forests of Asia and Africa. In adaptation to an existence passed in swamps and marshes, their feet carry several (three) toes. (Compare with pig.) By means of the rigid, powerful body and pillar-shaped legs, they can force their way through the most intricate jungle. (Compare with elephant.) They are protected even against the most formidable thorns by a horny, cutaneous armour, thick as a board, and consisting of several plates separated by folds of skin. In spite of this armour, however, the rhinoceros is not hindered in its movements, for the plates are easily shifted, and in the folds the skin is soft and thin (acting as joints

INDIAN RHINOCEROS. (The animal depicted in the foreground about one-fiftieth natural size.)

of the armour). The upper lip is elongated and finger-shaped, and with it the animal tears off branches from the trees and pushes them into its gigantic mouth. Its great weapons of defence are the horns carried upon the nose; of these the **Indian Rhinoceros** (*Rhinoceros indicus*) possesses *one*, the **African Rhinoceros** (*Rh. africanus*) *two*.

Family 3: Tapirs (Tapirina).

These are likewise survivals of a long-past age, "living fossils," and have some resemblance to swine. The tapirs (*Tapirus*) occur now only in a few species in the tropical forests of South America and Southern Asia, and are inhabitants of swamps and river-beds. Accordingly they

Digitized by Google

have a black skin, very short hair, four toes in front, three behind, provided with broad hoofs. They are peaceful vegetable feeders, with the snout prolonged into a short proboscis.

ORDER XI.: WHALES (CETACEA).

HAIRLESS, fish-like mammals, living in water. Hind-limbs absent, fore-limbs fin-like. Tail fin horizontal.

The Greenland Whale (*Balæna mysticetus*).

A. Distribution.

The Greenland whale is an inhabitant of the most northern parts of the Atlantic and Pacific Oceans. It is among mammals what the fish is among the vertebrates, an animal *restricted to an aquatic existence.* This fact explains—

B. Its Structure and Mode of Life.

1. This species and a few others of the same genus are the *largest* mammals of the present and of pre-existing times. It attains to a length of 68 feet, in some exceptional cases even 80 feet, and a weight of from 220,000 to 330,000 pounds (*i.e.*, equal to that of 150 to 200 strong oxen). An animal of such gigantic proportions *could only live in water, and, moreover, in the sea.* Let us inquire why. In most land mammals the body is supported on the two pairs of limbs, like a bridge on its pillars. To prevent the bridge from collapsing, its pillars must be strong, and its arches firm and rigid. If, however, the bridge is laid on the water (*e.g.*, a boat-bridge), it does not require so great a strength and solidity, since it is supported on the water at all points. From this comparison we may understand the strength of the larger land animals and the immense size of the whale, a size which is vastly beyond that of all land animals. (Compare also the size and firmness of aquatic plants.)

2. The whale dives down into the depths of the sea, more particularly when hunted (see below) or pursued. The pressure of water prevailing in these depths must be stupendous, as will appear from the following experiment: Discs of cork were attached to harpoons, which were thrown into the back of a whale and carried with him down into the depths; when the animal was dead, these discs were found to have been compressed to one half their former size. It seems at first sight incomprehensible how the animal can bear this immense pressure. It becomes, however, to some extent intelligible when we consider that most of the bones of the body remain cartilaginous at their points of union, that the two

Digitized by Google

halves of the mandible are only united by ligaments, and only the first pair of ribs is directly united with the sternum; all these arrangements tend to prevent fracture of the bones, and impart great elasticity to the body.

3. All land mammals possess as a protection against injury a more or less thick upper skin or integument. (Compare elephant and rhinoceros.) The skin of the whale, on the other hand, is remarkably thin, and as soft as well-greased leather (see Section 5, *i.*). (Compare in this respect the softness of the body of many aquatic animals.)

4. The whale has no hairy covering like that which protects land or amphibious mammals against excessive loss of body-heat (see p. 11); such a covering would be indeed utterly useless to the animal. (Why? See seal.) (A few bristles may be found here and there in exceptional cases.) On the other hand, the body is completely enveloped in a subcutaneous layer of fat (blubber) from 8 to 16 inches thick. (Compare with seal.) This excellent means for the *preservation of heat* enables the animal to inhabit even the ice-cold waters of the Arctic Seas.

5. The *movements* of the whale are remarkably nimble and rapid. In a few seconds it is able to escape from the reach of its pursuers. The animal may often be seen tumbling about in the water in play, suddenly lifting its gigantic body out of the waves, or standing on its head and lashing the water with its tail. This speed and extraordinary nimbleness is due to the following structural arrangements of the body:

(*a*) The body has the form of a boat, like that of a fish. (Compare with seal.) For this reason the whale used to be erroneously classed with the fishes, and in German still goes by the name *walfish*, *i.e.*, whale-fish.

(*b*) The head is united to the trunk without any visible *neck*. (Compare seal.) The cervical vertebræ are indeed present as in other mammalia, but they form only narrow rings or discs, which, moreover, are partially united with each other.

(*c*) Whilst in the seal the hind-limbs act pre-eminently as organs of locomotion, in the whale they (as well as the pelvis) are reduced to a few minute bones embedded in the flesh. The organ of locomotion of the whale is

(*d*) The *tail*, which is actuated by powerful muscles, and forms a gigantic fin. By its rotatory movements it acts just like the screw of a steamer in driving the animal forwards, while by its upward or downward strokes it enables it to sink below or ascend above the surface. The force located in the tail may be estimated from the fact that one stroke of it can shatter a stout boat.

Digitized by Google

(*e*) The *finlike fore-limbs* help to steer the body. The bones of the upper and lower arm (humerus, radius and ulna) are, as in the seal, very broad and much shortened, the hand only, the fingers of which are united by strong webs, projecting into the water. All the parts of the fore-limb are firmly united, there being no joints, with the exception of the shoulder-joint, and therefore the limb works as one piece. The action of the fore-limbs is, further, much assisted by the great *pliancy* of the body.

(*f*) The *subcutaneous fat* lightens the weight of the gigantic body in the water, as does also

(*g*) The *oil*, which permeates the porous *bones*, and

(*h*) The *lung*, which is of extraordinary size and extends further backwards than in land mammals, whereby the centre of gravity of the animal is shifted further forwards. The body during rest consequently

SKETCH OF BODY OF GREENLAND WHALE, WITH SKELETON MARKED IN.
(One two-hundredth natural size.)

B., Baleen; U., mandible; N., nasal opening, showing expired jet of water vapour; Bb., thorax; 1 R., first pair of ribs; Sch., scapula; O., humerus; Sp., radius; E., ulna; H., hand; B.H., bones of rudimentary pelvis and rudimentary hind-limb.

assumes a horizontal position. (How does this position affect respiration? See Section 6.)

(*i*) The *smoothness of the skin* has the effect of diminishing friction in the water. (Compare the mucus of the skin in fish.)

(*k*) *External ears* (pinnæ), which would impede the forward motion of the animal, are absent, nor are there any external auditory passages, as in all other mammals. Nevertheless, below the water the sense of hearing of the whale is so acute that it is said to perceive the strokes of an oar. The eyes are situated not far from the angles of the mouth; they are about the size of those of the ox.

(*l*) The extraordinary *nimbleness* of the animal is accounted for by the structural peculiarities of the skeleton referred to in Section 2, and

Digitized by Google

the great flexibility and elasticity of the vertebral column, owing to the presence of thick cartilaginous plates (intervertebral cartilages) between each two vertebræ.

6. The whale, like all mammals, *breathes* the free atmospheric air (not like fish, the air dissolved in the water). For the purpose of breathing it rises to the surface every ten to fifteen minutes, though wounded animals can remain below the water an hour and more. On rising to the surface to breathe, the whale expels the used-up air through the nostrils, with a noise audible for a considerable distance. Owing to the cold in these latitudes, the water vapour with which this air is saturated becomes visible (like the vapour of our breath in winter), and appears in the form of two huge jets of steam ejected from the head of the animal. It is this phenomenon which is spoken of as the "blowing" or "spouting" of the whale. (The whale does not eject a column of water like a fountain; why not? See Section 7, *e*.)

(*a*) Being obliged periodically to come to the surface, and the body of the whale being specifically heavier than water, there must be some mechanism for driving it upwards. This is provided by the powerful tail-fin, which accordingly has a horizontal position. (See Section 5, *d*.)

(*b*) The *nostrils* are placed on the summit of a roundish prominence on the top of the head, by which breathing is facilitated. Since the nose is in mammals adapted for smelling in the air, it is not surprising to find the olfactory nerve considerably atrophied in the whale.

(*c*) The *nostrils* form narrow slits. Their walls lie very close together, and the openings are closed by the pressure of the water when the animal dives, so that no water can enter through them. In breathing they are widely open.

(*d*) The remarkably large *lungs* take up an immense quantity of air, the animal requiring to respire only at long intervals.

7. *Food.*—The Greenland whale is *carnivorous*. It is impossible to estimate the quantity of food consumed by so colossal a creature. Only the sea, with its superabundance of animal life, can supply its demands. Owing to

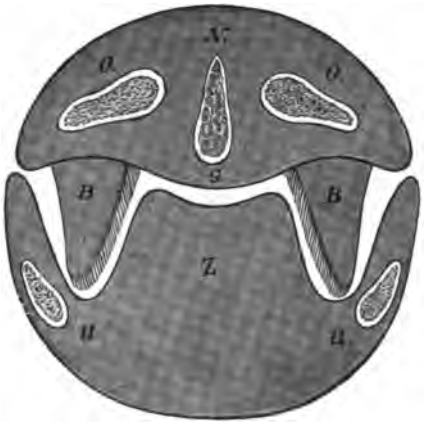
(*a*) The *remarkably small calibre* of the œsophagus, it is not capable of swallowing a fish larger than a herring. The food can accordingly consist of only small creatures. The native seas of the whale, in fact, teem at or near the surface, especially at the border of the drift ice, with myriads of small creatures, called by the whalers "whale-food." These innumerable shoals consist principally of an almost transparent Pteropod mollusc (*Clio borealis*), about 1¼ inches long. These are associated with equally large hosts of Amphipods from ⅔ to ¾ inch in length. (Some of these occur in our waters, *e.g.*, the common "fresh-water shrimp"

Digitized by Google

(*Gammarus pulex*). Of course, a huge creature like the whale cannot consume minute animals like this singly, but in shoals.

(*b*) For this reason, the immense toothless *mouth*, which could accommodate a small boat, is provided with an apparatus like a sieve or fisherman's net. From each side of the palate is *suspended* a row of triangular horny plates, like skins hanging from a roof. They are called "baleen," and furnish the "whalebone." (Why is this name a complete misnomer?) The baleen plates number from 200 to 300, those in the middle being the longest (up to 17 feet). The inner edges of these plates (the hypothenuse of the triangles) are the longest, and frayed out, as it were, into a close fringe of detached fibres of whalebone. As the whale

"WHALE-FOOD" (*Clio borealis*). (Twice natural size.)



DIAGRAMMATIC TRANSVERSE SECTION THROUGH THE HEAD OF THE GREENLAND WHALE, THE MOUTH BEING NEARLY CLOSED.

O., Upper jaw; N., nasal septum; G., palate; B., baleen; Z., tongue; U., mandible.

shoots through the water with the large mouth widely open, a large quantity of the marine molluscs and crustaceans before mentioned are taken in. When the mouth is now closed, the tongue, which resembles a lump of fat, and is firmly united to the floor of the mouth, is applied to the central part of the palate, which is devoid of baleen, and to the fringes of the baleen plates. In this way the water is forced out of the mouth, while the minute molluscs, crustaceans, etc., which have been caught in the fringes of the baleen are forced into the œsophagus. Anything left behind in this sieve is washed back by the next inflowing current of water. (Compare the beak of the duck and of ornithorhynchus),

(*c*) This adaptation of the mouth as a bucket, as it were, explains

Digitized by Google

the *large size of the head* (quarter to one-third the entire length of the body), and more especially the extraordinary *length of the jaws*.

(*d*) The shovel-like shape of the lower jaw is correlated with the flattened shape of the body.

(*e*) Whilst in all other mammals the food passes above the larynx (which on that account is provided with a lid), in the whale it passes *around* it, the larynx being firmly wedged into the lower nasal aperture (in the throat). This arrangement enables the whale *to breathe and swallow food simultaneously*.

(*f*) *Salivary glands* are absent, the food itself being extremely slimy. (See p. 8.)

8. *The Whale and its Offspring.*—(*a*) Being obliged, from the moment of their birth, to follow their mother in the water, the young are brought into the world in a high state of development, and perfectly capable of motion. (Contrast the young of the cat and kangaroo.)

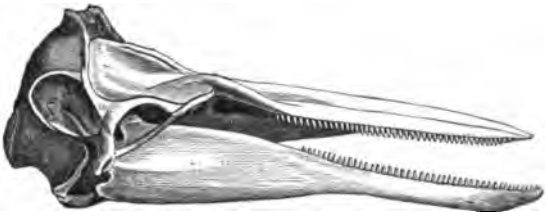
(*b*) The teats of the female lie within deep pouches on the abdomen. The young inserts the front part of its head into these, and grasps the teat with its lips. The lips, however, are but slightly mobile, and useless for sucking, for which reason the mother injects the milk by jerks into the mouth of the young, whereby it is prevented from mingling with the water.

C. Related Species.

In the same group as the Greenland whales (Whalebone whales, *Mysticetæ*) are the so-called "finner whales," which also inhabit the Northern seas, and take their name from the possession of a dorsal fin. The largest of this family, and, indeed, the largest existing animal, is the **Rorqual** (*Balænoptera sibbaldi*), measuring about 100 feet. Opposed to the Balænidæ or Toothless whales, we have the division of the Toothed whales (*Denticetæ*) the mouth of which is furnished with many pointed conical teeth of equal length. (See seal.) This oral armature, and the nimbleness and rapidity which distinguish all their movements, in themselves indicate sufficiently that we are here dealing with true carnivorous animals. Their food consists principally of fish, molluscs and crustaceans. One of them, the **Grampus** or Killer (*Orca gladiator*), goes specially in pursuit of seals and other whales, and when assembled in shoals will even attack the gigantic Greenland whale, tearing the flesh from its body piecemeal. The most familiar species of the North Sea and Baltic is the **Porpoise** (*Phocæna communis*), which belongs to the dolphin family. It only reaches a length of about 7 feet. Though its playful antics provide much entertainment to passengers on ships, it is much detested by sea-fishermen for plundering and tearing their nets. Another extraordinary member

Digitized by Google

of the family is the **Narwhal** (*Monodon monoceros*). The male carries in its upper jaw a huge straight tusk, often as much as 7 feet long, which was once believed to be the horn of a fabulous animal, the unicorn. As this tooth is absent in the female, it probably serves as a weapon with which the males fight for the possession of the female. (Compare with the antlers of deer.)



SKULL OF DOLPHIN. (One-sixth natural size.)

Of a size almost as gigantic as the Greenland whale is the **Cachalot**, or Sperm Whale (*Catodon macrocephalus*), which inhabits all seas except the Arctic Ocean. They derive their second name from a fatty substance, the spermaceti, which rapidly hardens on exposure to air, and is contained in special cavities of its enormous head. The pursuit of this animal is attended by considerable danger. With its powerful jaws it can bite a boat in two, and we are informed by credible authorities that in its terrible onrush it has even sent large ships to the bottom.

D. Importance of the Whale to Man.

The fact that a Greenland whale furnishes oil and whalebone to the value of from £750 to £1,500 furnishes a sufficient reason for the incessant pursuit of this species. All the other large species of the whale family have also been hunted for many years. Having provided themselves with provisions for several months, the whalers sail to the hunting-grounds. As soon as the look-out man observes the familiar jet of spray, boats are lowered and rowed with the speed of an arrow towards the prey. As soon as the boat is within fair range, a harpoon is hurled into the animal's body. Now is the moment for caution. The wounded animal lashes the waves in its fury and pain, plunges down into the depth, or takes to speedy flight, dragging the light craft along with it by the line of the harpoon. Now begins a race for life or death. If there are other boats at hand to harpoon it, or if it has been mortally wounded by the first attack, it is soon exhausted, and is then despatched with long iron spears. The gigantic body is next fastened with strong chains to the ship, which has come up in the meantime, and the work of cutting up and boiling down the blubber begins. After the whalebone has finally been removed the carcase is allowed to drift. In recent times whales are usually killed with bombs, which explode in the animal's inside and kill it instantane-

Digitized by Google

ously. In recent years numerous whaling-stations have been established on the northern coasts of Norway and Russia, whither the animals killed in the neighbourhood are dragged to be cut up. Here the flesh and bones also are converted into a valuable manure.

ORDER XII.: EDENTATES (EDENTATA).

Teeth either absent or reduced, destitute of enamel, and without roots. The digits carry long and powerful nails for scraping, or sickle-shaped claws for digging and grasping.

The Three-Toed Sloth, or Ai (*Bradypus tridactylus*).

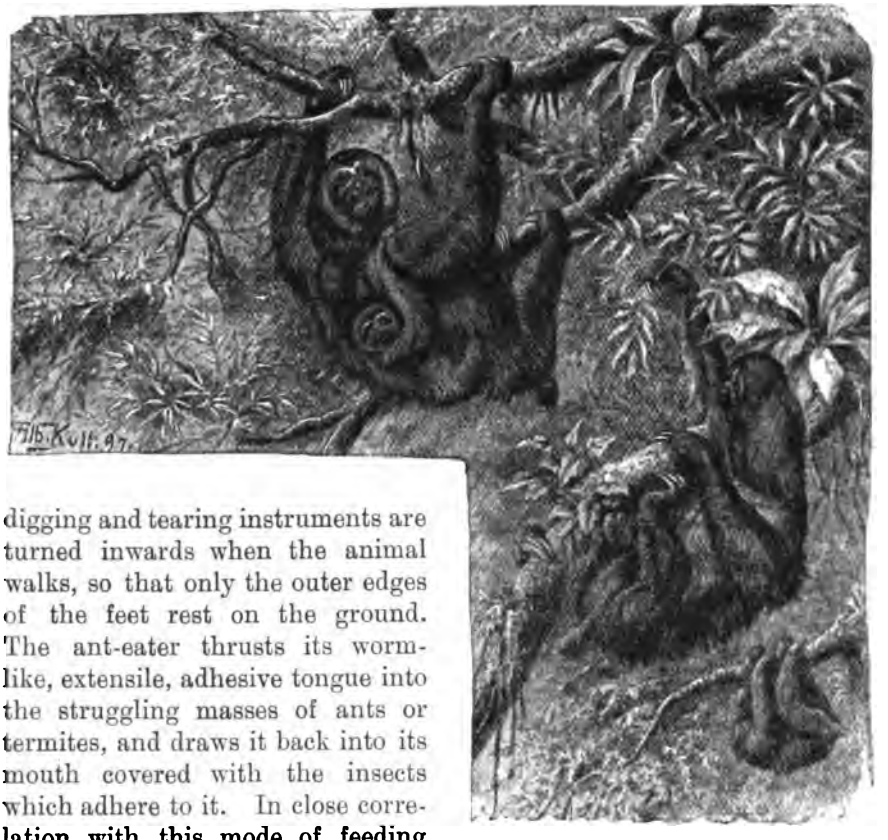
This animal is an inhabitant of the vast primeval forests of Brazil. Its habits are strictly arboreal. (Compare orang-utan.) By means of its long, sickle-shaped claws it climbs up trees, or hangs for days long on the branches, with its back turned downwards, without appearing to get tired. The articulations of the fore and hind limbs are far apart; in this way the animal is enabled to grasp branches at a considerable distance. The bones of the fore-limb are very movable, and the soles of the feet turned inward, an arrangement which greatly facilitates climbing. On the ground, however, the sloth is completely helpless; nor does it, except rarely, descend to the ground, since its food, which is always moist, provides it with sufficient water. The neck is extremely movable, allowing the animal, in spite of its suspended position while climbing, not only to look straight in front of it, but also to turn its head right round towards its back. The two first thoracic vertebræ have no ribs, and thus the seven cervical vertebræ which all other mammals possess are increased to nine. It is able to support itself on, and to progress along, branches of extreme thinness — a fact which protects it from most of the climbing carnivora. Against the larger birds of prey (eagle) it is protected by the colour of its coat, which consists of long, dry, coarse hairs. An animal suspended at rest from a branch or sleeping in the fork of a tree bears an exact resemblance to a large cushion of dry moss or a bundle of lichens. In correspondence with its usual suspended position, the hairs are directed from the belly towards the back, so as to allow the rain to drain off. In spite of the slowness of its movements, it can always find food in sufficiency, the primeval forest almost placing it within its mouth.

Related Species.

The relatives of the peculiar sloths are animals no less peculiar. One of them is the **Ant-eater** (*Myrmecophaga jubata*), which lives in the

Digitized by Google

eastern part of South America. It is covered with a coat of bristles of a gray-black colour, raised along the back into a coarse mane-like crest, which is continued into the bushy tail. The latter forms about half of the total length, which measures about 6½ feet. This tail is spread over the body when the animal sleeps. Its food consists chiefly of ants and termites ('white ants'), whose nests it opens by means of the powerful claws on its fore-feet. To protect them from wear, these important



FAMILY OF THREE-TOED SLOTH. (One-tenth natural size.)

digging and tearing instruments are turned inwards when the animal walks, so that only the outer edges of the feet rest on the ground. The ant-eater thrusts its worm-like, extensile, adhesive tongue into the struggling masses of ants or termites, and draws it back into its mouth covered with the insects which adhere to it. In close correlation with this mode of feeding are the tubular form of the facial region, which is a mere sheath for the tongue, the small size of the mouth aperture, and the complete absence of teeth. The same peculiarities occur in the structure of the **Scaly Ant-eaters** (*Manis*), which are natives of Africa and the East Indies, and also live on ants. They carry, however, a peculiar scaly armour, which gives them the appearance of a moving pine-cone.

Digitized by Google

When alarmed, they immediately roll themselves into balls like the hedgehog, so that the sharp edges of the scales are presented. The plates overlap like the tiles of a roof, and are formed of united hairs. The armour thus forms an effective protection for the slow and inoffensive creature. The lower side of the body is covered only with ordinary hair. A similar armour is possessed by the **Armadillos** (*Dasypus*), which live in South and Central America; the skin of the back is modified into movable rings or girdles consisting of plate-like shields, each containing a plate of bone, as in some reptiles. The teeth are numerous, but very weak, and the animals further protect themselves by burrowing with their powerful claws into the ground. There, also, they find their food, which consists chiefly of insects.

ORDER XIII.: MARSUPIALS (MARSUPIALIA).

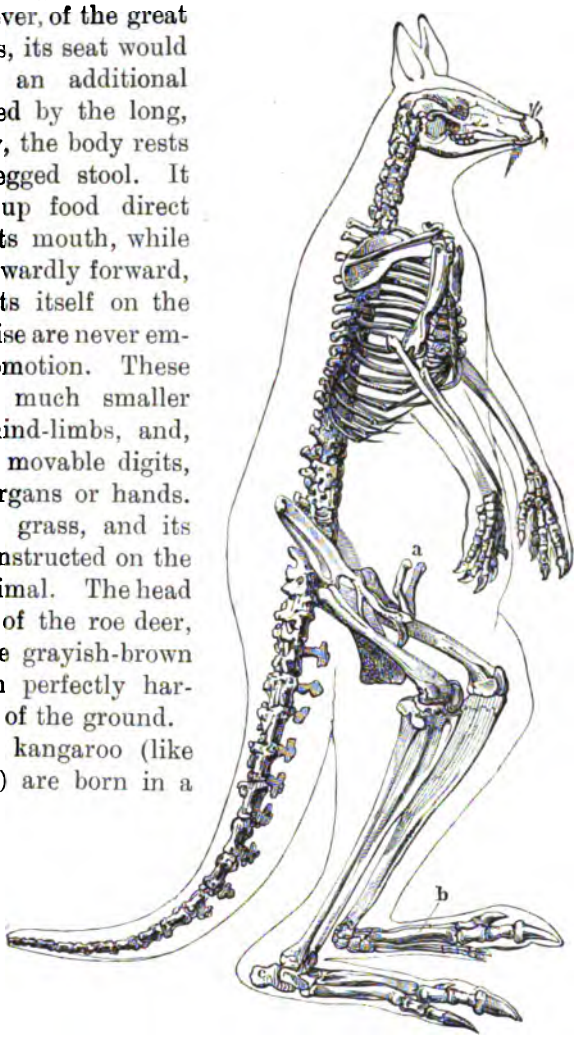
ANIMALS provided with an abdominal pouch, or marsupium, in which are contained the nipples of the mammary glands, and in which the young are suckled during their early, imperfectly developed, condition. The abdominal wall is supported by two so-called marsupial bones. The teeth vary in number and shape, according to the kind of food (conforming to the carnivorous, insectivorous, herbivorous, or rodent types). All the marsupials are limited to Australia and America.

The Great Kangaroo (*Macropus giganteus*).

This animal is an inhabitant of the Bush and the grassy plains of Australia. Its ordinary mode of progression is by a series of leaps and bounds. In accordance with this habit, the hind-limbs, as in all other leaping animals (*e.g.*, hare, grasshopper, flea), much exceed the fore-limbs in length and strength. This mode of progression, however, calls forth a considerable amount of bodily force, which has its seat in the muscles of the thigh. Moreover, the posterior portion of the body is of remarkable size and strength as compared with the small head and the chest. In taking a leap, the animal uses especially its middle toe, which is very long and carries a powerful claw, as a prop or support against the inequalities of the surface (this middle toe, in the absence of a thumb and the concrescence of the second and third toes, corresponds to the fourth toe in the human foot); it then, by exercising pressure on the elastic hind-legs, is jerked upwards and flies like an arrow through the air. When suddenly alarmed, the animal can execute a leap of more than 33 feet. In its leaps it clears bushes as well as ravines, so that in mountainous or wooded districts even the quick-footed

Digitized by Google

dog or horse fails to come up with it, these animals being obliged to circumvent intervening obstacles. When at rest, the kangaroo sits only on its hind-legs (not on the posterior portion of its body, like, *e.g.*, many rodents). In spite, however, of the great length of the metatarsals, its seat would not be very secure if an additional support were not afforded by the long, strong tail. In this way, the body rests as it were on a three-legged stool. It is only when picking up food direct from the ground with its mouth, while limping slowly and awkwardly forward, that the animal supports itself on the fore-limbs, which otherwise are never employed as means of locomotion. These limbs, accordingly, are much smaller and weaker than the hind-limbs, and, being provided with five movable digits, are used as prehensile organs or hands. The kangaroo lives on grass, and its teeth are accordingly constructed on the plan of a herbivorous animal. The head strongly resembles that of the roe deer, as does also the skin, the grayish-brown ground colour of which perfectly harmonizes with the colour of the ground.



SKELETON OF (FEMALE) KANGAROO.
(With body, one-thirteenth natural size, in outline.)
a, Marsupial bones; *b*, metatarsus.

The young of the kangaroo (like those of all marsupials) are born in a much less perfect condition than those of all other mammals. While, in the sitting posture, the parent animal attains to about a man's height, the young does not exceed about ¾ inch in length, is completely naked, blind, and the limbs are merely rudimentary stumps. Naturally, so helpless a creature is still in need of special care. This it finds in the brood-pouch of the mother, which is a large fold of the abdominal integument. Immediately after birth

Digitized by Google

the mother gently seizes its young offspring and conveys it into this receptacle, where it finds protection, warmth and nourishment. It at once presses its lips tightly to one of the nipples, and begins to advance rapidly in growth. The abdominal wall of the mother is supported by two so-called marsupial bones developed from the brim (pubic bone) of the pelvis, by which the young is protected against the pressure of the abdominal viscera of the mother. After about seven months, it for the first time protrudes its head from the pouch, which it now soon leaves for shorter or longer periods, but in which long afterwards it seeks refuge at the approach of danger.

Related Species.

This mode of reproduction is proper to all other marsupials. It is this which unites the numerous members of the order. For in structure and mode of life the marsupials are by no means a uniform group, like the rodents or apes, for example. On the contrary, they are of various types, and in their characters repeat the principal forms of the whole diversified class of mammals. The rodents are represented in structure and mode of life by the wombat (*Phascolomys*), which is about as large as a spaniel, and lives in burrows like a rabbit. The marsupial weasel (*Dasyurus*) and the marsupial wolf (*Thylacinus*) represent the carnivora. There is also an aquatic marsupial with swimming feet, arboreal species with hands and grasping feet, even a subterranean form which has been aptly called the marsupial mole (*Notoryctes typhlops*).

Geological discoveries prove that the marsupials in long-past ages were spread over the whole earth. As, however, the structure of these animals was not adapted to their mode of life in the same high degree which we have seen in other mammals, it was inevitable that they should gradually give place to the latter, and so vanish from the earth. In isolated Australia and the neighbouring islands, however, like the egg-laying monotremes, they were able to survive to the present day; for there, as there were no other mammals, they were not exposed to such a war of extermination. Now, however, they are gradually giving place to the mammals introduced by man (rabbits, rats, sheep, etc.).

Also in America a few species survive—the opossums, which are characterized by their long, almost naked, scaly tails (*Didelphys*). The best-known of these is the *D. virginiana*, the most notorious poultry-thief of North America, whose fur is valued in Europe.

Digitized by Google

ORDER XIV.: CLOACAL ANIMALS (MONOTREMATA).

Oviparous mammals in which the urinary and intestinal organs open into a common chamber, the cloaca, as in birds.

The Duck-Mole (*Ornithorhynchus paradoxus*).

(Length, including tail, 20 to 24 inches.)

This animal is an inhabitant of South-Eastern Australia and Tasmania. Like the otter and beaver, it is a truly aquatic animal, whence it is rightly called "the water-mole" by settlers. For the same reason, the structure of its body agrees in many respects with that of the animals named (which see). The coat is thick, and is not wetted by the water; the head is small, the neck short, the body elongated;

Duck-Mole. (One-tenth natural size.)

the tail is used as a rudder; the legs are very short; the feet are provided with swimming membranes or webs, and are used as oars. External ears are absent, and the openings of the auditory passages can be closed. Like the otter and beaver, the animal, with the strong claws of its toes, digs burrows on the banks of rivers. The dwelling consists of a small chamber from which two passages lead out, and terminate, one above and one below the surface of the water. The structure of its mouth, however, at a glance distinguishes the animal from the otter and the beaver. It differs from all other mammals by the absence of lips, in place of which the integument of the jaws is cornified and produced in the form of a beak exactly resembling that of a duck. Like a duck, too, the animal rummages among water-plants and in the mud after worms, insect larvæ, slugs, and more

Digitized by Google

particularly molluscs. In closing its mouth, the water (as in the duck) runs out through the "strainers" in the mandibular portion of the beak, while the prey is retained. To prevent water entering the trachea, the food is stored up in the cheek-pouches (see marmot) until the animal comes again to the surface. In the adult animal the beak is toothless (a few small teeth, which soon drop out, are developed in the young). Seeing that the favourite food of the duck-bill consists of hard-shelled molluscs, the absence of teeth appears an advantage rather than a deficiency. In the cracking of the hard shells of these animals teeth would very soon get worn away; this is not the case with the thick, horny margins of the jaws. A horny fold at the base of the beak protects the fur against being soiled by the mud whilst rummaging.

The duck-bill does not bring forth living young, but lays eggs, like birds and reptiles. These are hatched out in the padded chamber of its burrow by the heat of the mother's body.

Related Species.

There are only two other well-known species of this order, viz., the **Spiny** and **Long-Haired Ant-eaters** (*Echidna hystrix* and *setosa*). These animals in external appearance (coat of spines) resemble our hedgehog. In correspondence with their habit of feeding on ants, they possess, like the ant-eater, powerful digging claws, a tubular face with very small mouth, and a long worm-like adhesive tongue. In these species the eggs are hatched in a pouch situated on the abdomen. They inhabit Tasmania, Australia and New Guinea.

Digitized by Google

PART II.

CLASS II.: BIRDS (AVES).

VERTEBRATE animals with warm blood, breathing by means of lungs, with a covering of feathers, the fore-limbs forming organs of flight, or wings; oviparous, laying hard-shelled eggs.

Birds live under the most varying conditions, necessitating special bodily arrangements. (Thus, in swimming birds the feet are adapted for swimming—webbed; in cursorial birds, for running, etc.) All, however, agree in their most essential features, for all, with few exceptions (cursorial birds and penguins), *possess in common one faculty, viz., the power of traversing the air by flight.*

1. **Body.**—The body of a bird, which in its flight has to overcome the resistance of the air, like a ship which ploughs its way through the waters, has the form of a spindle. (What is the import of this particular shape in the case of moving objects?)

In flying the bird has to make active movements with its wings, the organs of flight. If the muscles by which the wings are moved were attached to bones capable of free motion upon one another, their action would be considerably weakened; for in order to execute their work efficiently the muscles require firm points of attachment. Therefore the skeleton of the trunk in birds is *firm and rigid*, like the hull of a ship. This general compactness and rigidity of the body results from the following skeletal arrangements:

(*a*) The *vertebræ of the trunk* form one complete, continuous, and almost rigid whole, differing in this respect from those of mammals, which are more or less movable *inter se*, and divisible into three distinct sets, viz., the dorsal, lumbar, and sacral portions of the spinal column. The dorsal vertebræ, which carry ribs, are but slightly movable upon one another; the lumbar and sacral vertebræ are anchylosed into one continuous portion, the so-called "sacrum." Accordingly, muscles serving to move these vertebræ are almost entirely absent. (This effects a diminution in the body weight.)

Digitized by Google

(*b*) The thorax receives additional support from the *ribs*, which are completely ossified, even to their lower (sternal) segments, which in mammals remain cartilaginous (see, however, bat), and from processes, the so-called *uncinate processes*, one of which arises from the posterior margin of each rib, and is applied to the rib next in succession behind.

SKELETON OF THE GOLDEN EAGLE, WITH THE BODY SKETCHED IN OUTLINE.

U., Mandible; Qu., quadrate bone; J., jugal bone; Hw., Bw., Sch.W., cervical, dorsal and caudal vertebræ; Ra., coracoid; G., furcula; B., sternum, with (BK.) sternal crest; R., ribs; Be., pelvis; O., humerus; Sp., radius; E., ulna; Hw., carpus; M., metacarpus; I., II., III., digits of the fore-limb; the same letters and IV. denote those of hind-limb; Osch., femur; Sch., tibia; W., fibula; L., tarso-metatarsus.

(*c*) The connection of the wings with the thorax by means of the shoulder-girdle, although very light and free (why is this necessary?), is nevertheless exceedingly strong. In mammals the shoulder-joint is placed only between the humerus and the shoulder-blade, or at most has

Digitized by Google

an additional support from the collar-bone (see Part I., p. 11). In birds, on the other hand, the joint is placed at a point where three bones meet. The first of these bones is the shoulder-blade, or scapula, which lies close against the thorax; the second is the coracoid, which connects the scapula with the sternum; and the third is the collar-bone, or clavicle. The two clavicles are anchylosed with one another at their anterior extremities, forming a V-shaped bone, the "furcula," popularly known as the "merry-thought." In this manner the clavicles assume the form of a bent rod of great elasticity, an arrangement of the highest importance to the avian body. The function of this furcular arch is to hold off from the thorax, and thence from the internal organs (lungs, heart, etc.), and to transfer to the scapular joint, the extra pressure which would otherwise fall on these parts in the simultaneous downward stroke of the wings. This action may be exemplified by a bridge, in which the pressure is transferred to the buttresses of the supporting pillars. (How do mammals as a rule move their fore-limbs?)

2. **Tail.**—A long tail, such as is found in most mammals, would to a bird entail an unnecessary load, and, moreover, would be much too difficult to manage as an *aerial rudder*. Hence the tail is always short and enclosed within the integument. Its terminal portion, which is formed by the anchylosis of several vertebræ, is almost always of considerable size, and *supports* the *rectrices*, or *steering feathers* (see Section 10, *a*). As it is necessary that the rudder should be movable, the vertebræ which immediately precede this terminal portion are *freely* movable on one another, and do not anchylose like those of the trunk.

3. **Fore-limbs.**—The forward movement of a bird is effected by the stroke of the wings, as that of a boat by the oars. The wings, in fact, form *the oars of an air-boat or balloon* (see Section 11). Of all modes of motion, however, flight is the most difficult, for not only has the flying animal to perform appropriate movements in order to progress forwards, but has also, while "swimming" through the air, to carry the whole weight of its body. (Why? Compare with terrestrial and aquatic animals; and see the whale.) Accordingly, the bird must be endowed with *great power* in its organs of flight; this necessitates *powerful muscles* and large *bony surfaces* for their attachment. These are provided by the bones of the shoulder-girdle, and especially by the long, broad, and shield-like *sternum*, the surface of which is further increased by a remarkably *large bony keel*, or *crest*. (Compare, however, the ostrich. Why may this crest be comparatively thin? Consider that the wings are depressed *simultaneously*.) These large muscles of the thorax, however, do not merely act as the motor engine of the living air-ship, but, in combination with the heavy viscera (see stomach), also supply its ballast. Con-

Digitized by Google

sequently, the centre of gravity of a flying bird invariably comes to lie in the lower part of its body, so that the body, hanging in the shoulder-joints, as it were, is always in a condition of stable equilibrium (something like a ship's lamp, which is kept vertical, however much the ship pitches or rolls).

WING FOLDED TOGETHER.
(For explanation of figures, see illustration, p. 140.)

Although the wings deviate in form considerably from the fore-limbs of mammals (why?), they are nevertheless constructed on exactly the same plan (see Part I., p. 12). In the wing of a bird, as in the fore-limb of the mammal, we distinguish three portions, viz., the *upper arm* (humerus), the *lower arm* (radius and ulna), and the *hand*. In the hand we may, indeed, still distinguish the carpus, metacarpus, and digital bones; but in the adult bird these bones are in part anchylosed with each other, and in part rudimentary. The three digits which remain correspond to the thumb and the second and third fingers of the human hand. When at rest, and during all other movements of the bird, except flight, the wings are laid close against the body in the form of a Z. (Why? Compare, however, the illustration of the penguin.)

4. **Hind-limbs.**—All birds are occasionally obliged to descend upon the earth or upon solid objects. (Why?) Even those whose life is almost entirely passed in the water (penguins) must come on shore for the purpose of breeding. Hence the hind-limbs cannot *likewise* be developed into organs of flight (compare, on the other hand, with fishes), but must take on the form of *legs*, enabling the bird to progress along the ground, or, at least (swallows, etc.), to obtain a hold on solid objects. In many birds the legs are, of course, adapted by special arrangement for other activities besides (compare scansorial, natatorial, raptorial birds, etc.); the structure of these organs, however, must in all birds be essentially the same, since all are employed in one and the same kind of work (walking or running, and holding on to solid objects). As in mammals, the leg consists of three distinct portions: the *thigh* (femur), which is always concealed within the body; the *leg* proper (tibia and fibula), the latter usually very rudimentary); and the *foot*. The bones of the tarsus are not separate in the adult bird, coalescing, even during development within the egg, partly with the tibia, partly with the metatarsal bones. The latter likewise coalesce, and, in combination with the lower tarsal bones, form a long tubular bone, the *tarso-metatarsus*. (Locate the knee and ankle joints in the bird's leg.) All birds

Digitized by Google

walk on their toes (digitigrade). As a rule, four of these are present, corresponding to toes 1 to 4 in the mammalian foot. (In what birds is the number of toes less?) As birds stand only upon two limbs, they require a large surface of support, which is obtained by the length and spread of the toes. (Man walks on his soles. We can walk on stilts, but cannot stand still on them.) The innermost digit, the 'great toe' or hallux, is generally directed backwards (posterior toe); the second, third, and fourth form the anterior toes. (In which birds does the position of the toes deviate from this arrangement?

Inasmuch as the bird is limited to two limbs in its motions on the ground, the body is carried more or less upright, in order to be kept in equilibrium, and for the same reason the legs are generally perfectly developed (name any exceptions, and explain their reason), and firmly united with the vertebral column. The latter result is due to the fact that the bones of the pelvis are firmly anchylosed with each other, and with the immovable sacrum. (In man also the pelvis is anchylosed with the sacrum. Why?)

Another peculiarity of the bird's leg deserves special consideration. Many of our birds spend the whole day hopping about among bushes and in trees, the branches of which they clasp with their toes; and even their *night rest is spent* in this sitting position upon branches. It would be impossible for us to maintain ourselves in this position by means of our feet (why?), nor could we, like birds, hold on with our hands to the branches of trees for hours at a time, for the overexertion of the muscles would soon become too painful to endure. Birds, however, are not tired out by these efforts, and can maintain a sure and firm seat on the branches even during a storm. How are they enabled to bear this strain? If we carefully remove the skin from the leg of a bird, we observe a long tendon passing off from a special extensor muscle (*a*) attached to the pelvis, over the knee-joint (*b*), thence along the leg backwards across the heel-joint (*c*), down the tarso-metatarsus, and finally uniting with the toes at *d*. The contraction of the muscle must result in the flexion of the toes. *The same result, however, is spontaneously attained without the intervention of the muscle whenever the leg is bent upon the thigh*, inasmuch as the tendon is stretched by the flexion. (If we bend the knee, the leg of our

LEG OF A BIRD, WITH THE SKIN REMOVED.
The ligament b_1 holds the tendon in its place. The other figures are explained in the text.

Digitized by Google

trousers is stretched, and appears to shorten below.) In a roosting bird, the flexion of the knee results from the weight of its own body. By laying its head over its back during sleep (see mobility of the neck), the centre of gravity of the body comes to lie exactly over the legs, so that the branch on which the bird is roosting is clasped still more tightly. (What is the probable purpose of this tucking in of the head under the wings? Associate it with the fact that we fall asleep sooner if we draw the coverlet over our heads.)

5. **Head and Neck.**—It has been seen that the primary function of the leg of a bird is to enable the animal to progress along the ground and to hold fast to other objects. In many birds the hind-limb assumes the secondary functions of an oar in the water, of a rudder during flight, as an instrument for holding fast the prey, etc. (Give examples.) But for most of the important functions of life—the collection of food, building of the nest, feeding and care of the young, preening and lubrication of the feathers (see section 10, *d*), etc.—the hind-limbs are as little adapted as the wings, for they are required for supporting the bird during the performance of these various activities. It is the *beak* to which is assigned the task of performing these several functions. This organ is used like a pair of forceps; it represents, in fact, the "fingers" of the bird, whilst the head represents its "hand."

To be capable of performing the functions of a hand, it is of primary necessity that a limb should be freely movable, as, indeed, we find to be the case with the parts which perform these functions in the bird. All birds possess a (relatively) *long neck*, consisting of a large number (8 to 24) of vertebræ movably articulated to each other, and thus rendering the neck capable of free motion in all directions. The head, too, can be turned with ease in all directions, being united with the first cervical vertebra by only a *single occipital condyle*. (In mammals the vertebræ are only slightly movable *inter se;* and there are two occipital condyles. How do these arrangements affect the mobility of the head?)

The *absence of teeth* is correlated with the function of the beak as a prehensile organ, or "finger." Teeth necessitate strong jaws, and these in their turn powerful muscles for moving them as well as the teeth. Powerful muscles, again, require large bony surfaces for their attachment. Teeth, in short, require a large and heavy head, such as could not be supported by the thin neck of a bird (compare the giraffe and the elephant.

For the purpose of flight, also, it is necessary that the head and neck of a bird should be *as light as possible*. If heavy, these parts would drag the flying animal towards the ground. (For a similar reason, the large pectoral muscles which move the wings and the strong muscles of the leg

Digitized by Google

do not lie upon the limbs themselves, but as centrally as possible upon the trunk.)

To compensate for the absence of teeth (see also stomach) the jaws are covered by horny sheaths, which are light and generally strong, and constitute the beak. The mandible is not directly connected with the temporal bones, but is articulated with the skull on each side by the intervention of a special *quadrate bone*. Between the lower part of this bone and the upper jaw are inserted two bridges of bone, the palatal arch and the jugal arch (the latter is visible in the figure on p. 140). When the mandible is lowered the lower part of the quadrate is drawn forwards. This movement by means of the two bony arches is transferred to the upper jaw, and as this is connected with the forehead by a kind of joint, the upper jaw must be more or less raised. This is especially the case in parrots.

6. **Special Characteristics of the Bones of Birds.**—The lighter the body of a flying animal, the greater the ease with which it can move through the air. (Why?) Hence, in the structure of the avian body the weight is reduced to a minimum. In addition to great *hardness*, *strength* and *elasticity* (why is the latter quality indispensable?), the bones of birds are distinguished by their extraordinary *lightness*. Many of them are also hollow, and filled with air instead of heavy marrow. This peculiarity of the bones (pneumaticity) is by no means a disadvantage, since, provided their walls be not too thin, tubular rods are much stronger, and hence *less easily broken*, than solid ones of the same length and weight (show by experiment with glass tube and glass rod; compare also the blade of grasses); whilst hollow bones offer much larger surfaces of attachment to the muscles than solid ones of equal length and weight. (Roll up a piece of paper tightly so as to form a rod, and also another piece of the same size into a tube, and compare the surfaces of the two.

7. **Organs of Respiration.**—If air be blown through the trachea of a dead bird, the *whole body* is observed to become strongly inflated. (What part only would be inflated in a mammal?) This is owing to the presence of numerous large air-sacs connected with the lungs and distributed among the intestines, in the neck and among the muscles, and sending off branches into the cavities of the bones. These sacs may be compared with extremely thin-walled indiarubber balls, and when filled with air *do not add* * to the weight of the body. What is the function of these air-sacs? If the thorax of a bird during flight were to undergo alternate

* When the air-sacs are inflated the weight of the body is increased by the weight of the air taken in, but this is exactly counterbalanced by the upward pressure of the additional air displaced. The increased *surface* of the body, however, offers additional resistance to the air in falling.

Digitized by Google

contraction and expansion, these movements would considerably affect the action of the organs of flight, which require fixed points of support. These movements, accordingly, must be prevented without the bird's respiration being interfered with. A man cannot breathe easily when his arms are performing some strenuous labour, *e.g.*, lifting a weight. In birds, however, by means of the air-sacs, the respiratory function can proceed uninterruptedly during flight. Owing to the bird's rapid flight through the air, and the resistance of the latter, air is forced from without through the lungs into the air-sacs (inspiration). (This forcible entrance of air into the lungs is experienced in ourselves when walking against a strong wind.) By the strokes of the wings, on the other hand, the air-sacs which lie between the shoulder-joint and the pectoral muscles are compressed, and the air contained within them pumped out through the lungs (expiration).

This also explains why a bird can travel at heights in which no mammal could exist for any length of time. Birds have been observed flying at heights of as much as 40,000 feet (nearly eight miles). In consequence of the enormous speed at which birds fly in these altitudes (the carrier pigeon traverses 66 feet, and even more, per second, and the swift about three times that distance), the air in the air-sacs is at a *high pressure, so that respiration does not proceed at the pressure of the surrounding medium.* (Why must a flying bird move rapidly? Compare the speed of so-called "bad" flyers with that of the fastest mammals. Why do "bad" flyers —*e.g.*, domestic fowls—always fly close to the surface of the earth—*i.e.*, in the denser layers of the atmosphere?)

Their manner of breathing also explains why birds never "get out of breath" (like a mammal), even during their most rapid flights. Birds such as swallows, which have been careering about for hours, will settle down quietly without the least acceleration being noticeable in their breathing. During rest, and all other movements except flight, respiration is carried on, as in mammals, by means of alternate enlargement and contraction of the thorax. But, as the lower segments of the ribs are ossified and no diaphragm is present, the means by which these changes are produced are somewhat different. The illustration on p. 140 shows that the two portions of each rib are not in one direction, but meet at an angle. When this angle is increased by muscular action, the lower portions of the ribs being straightened out, the sternum is necessarily lowered. The cavity of the body is thus increased, and the lungs must take in air (inspiration). When the angles of the ribs are again decreased, the cavity becomes smaller, and the air is driven out of the lungs (expiration).

The upper end of the trachea commences, as in mammals (see Part I.,

Digitized by Google

p. 6), with a *larynx* (superior larynx). Since, however, no vocal cords are present in this organ, it cannot be used for the production of sound. The real vocal apparatus of birds is formed by a dilatation of the lower end of the trachea, the so-called *lower larynx* or *syrinx*, in which vocal cords are present, and which in the song-birds displays a specially high degree of development.

8. **Organs of Digestion.**—As has been seen above, flight is the most difficult form of motion, and entails a very great expenditure of force. This in its turn conditions a large consumption of food (see Part I., p. 8), and a bird spends almost the whole of the time when he is not asleep in the eager search for nourishment.

In the absence of teeth (see Section 5), the task of crushing the food devolves upon the *stomach*. This organ varies in structure according to the nature of the food, whether this consists of hard or soft substance (grain and hard-shelled insects, or the flesh of vertebrates, snails, soft-bodied insects, etc.). In the former case the stomach is highly muscular, forming a *gizzard, which crushes and grinds like the stones of a mill* (see pigeon); in the latter case it consists of a membranous sac (see the buzzard), in which the flesh food is dissolved by the strongly acid gastric juices as in a chemical retort (*retort-stomach*). For remarks on the tongue, salivary glands, œsophagus and crop, see under the treatment of the separate species. Birds have no urinary bladder. (This effects a saving in body-weight.) The ureters, the intestine and the oviducts terminate in a common receptacle, the *cloaca* (see also duck-bill). The urine of birds is white, and is discharged simultaneously with the fæces.

9. **The Heart** is constructed on the same plan as in mammals (see Part I., p. 16).

10. **Feathers.**—Increased consumption of food has the effect of increasing the heat of the animal body, which is produced by its combustion (see Part I., pp. 7, 8). Birds accordingly are *warm-blooded creatures*. The temperature of the body must, however, be kept at the same height, in order to prevent any interruption or cessation of the internal activities of the body. Birds therefore require (like mammals, see Part I., p. 11) special means for *conserving the body-heat*. These are provided primarily by the numerous warm air-spaces among their thick, warm plumage. The air in the air-sacs likewise acts as a heat-conserving agent. (Birds while roosting, or in cold weather, vigorously fill their air-sacs with air, so that the feathers come to stand on end, as may be easily observed in sparrows or canaries. In this way the organs of the body become, as it were, enveloped in air, and the spaces between the feathers still further enlarged.) Fat is met with in birds only exceptionally (swimming birds) as a means for conserving body-heat, since it would load the body too

Digitized by Google

much. (Why do we not meet with birds possessed of an armour-like shell, like, *e.g.*, the tortoises?)

(*a*) *The Different Kinds of Feathers.*—The feathery covering of a bird is made up of *two kinds of feathers*, viz.: down-feathers, which form an under-coat; and larger clothing or contour feathers, forming an upper covering for the body which shuts off from the outside the warm layer of air enclosed by the soft hairy down-feathers. (In what direction are the contour feathers disposed, and why?) The contour feathers are called after the parts of the body which they cover (neck-, shoulder-, breast-feathers, etc.). The large feathers at the posterior margins of the wings, which convert the fore-limbs into broad, oar-like surfaces, are termed *flight-feathers*; those which convert the tail into a rudder the *tail-feathers* or "*rectrices*."

K.

LOWER PORTION OF A QUILL FEATHER.

K., Scapus; Sp., quill or calamus; F., vane; S., pith.

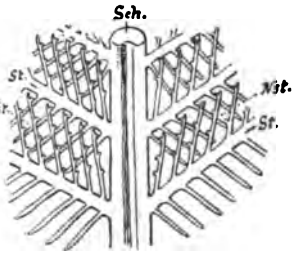
(*b*) *Parts of a Feather.*—A fully-developed feather consists of the following parts: a firm *stem* (*scapus*), which supports the whole structure, and the real blade of the feather, the *vane* or *vexillum*. The lower, generally transparent, portion of the stem is known as the *quill* or *calamus*, while its upper portion, which contains a pith-like substance analogous to marrow, is termed the *shaft* or *rachis*. The quill of a perfect feather contains a fine dry membrane or *pith* which, while the growth of the feather is still incomplete, is traversed by bloodvessels. The vane consists of a series of horny plates, the *barbs*, placed obliquely along the shaft, and giving off pointed processes, the *barbules*, from their anterior and posterior margins. The anterior barbules are generally provided with small *hooks* which interlock with the posterior barbules of the preceding barb, the vane thus coming to form a connected whole. (This is especially important in the case of the wing-feathers, see Section 11.)

(*c*) *Moulting of the Plumage.*—As a rule, with the beginning of autumn the bird changes its plumage, a process known as *moulting*. It then assumes what is known as the winter dress, which changes its colour, especially in the males, with the approach of spring (spring moult), being now changed into the *wedding* or *breeding dress*, from the fact that it is assumed at the pairing and breeding season. The plumage of the young

Digitized by Google

(*nestling plumage*) is generally of simpler colour than that of the old birds (see partridge). The plumage of the female also is generally less brilliant than that of the males (see chaffinch).

(*d*) *Lubrication or "Preening" of Plumage.*—Being composed of a very light substance (horn) and almost filled throughout with air, feathers contribute to a marked degree to the diminution of the specific weight of the avian body (see Sections 6, 7). If wetted by the rain, they would not only tend to increase the body-weight, but their function as a heat-conserving agent would be considerably affected. Accordingly, the feathers are periodically lubricated ("preened") with an oily fluid, secreted by a special *oil-gland* (uropygial gland) found in all birds (with few exceptions) at the root of the tail above the posterior caudal vertebræ. This gland is specially large in birds which are much exposed to wet (swimming birds). (Compare also in this respect the length and mobility of the neck. How does the beak of a bird serve it as comb and brush?)



DIAGRAMMATIC REPRESENTATION OF THE STRUCTURE OF THE VANE OF A FEATHER.
Sch., Rachis or shaft; St., barbs; Nst., barbules.

TIP OF WING FROM BELOW.
Vf., Anterior vane; Hf., posterior vane.

11. The Flight of Birds.—(*a*) *How does a bird maintain its position in the air without falling?*—The body of a bird is heavier than the air. To prevent itself from sinking to the bottom of the aerial ocean—*i.e.*, the surface of the ground—the bird, except when kept up by the wind (soaring), is obliged to execute suitable movements, exactly like a man swimming in water. As the latter prevents himself from sinking by powerful upward strokes of the arms, and rises upwards with each repeated stroke, so in like manner the bird prevents itself from falling by downward strokes of its wings, and with each new stroke raises its body further upwards (see also Section *c*).

(*b*) *How are the wings adapted for this function?*—A bird deprived of its flight-feathers is incapable of flight, and only recovers this power after their renewed growth. It is these feathers, accordingly, which render the wings capable of serving as an organ of flight; for, by converting the narrow limbs into broad surfaces, they enable these organs to execute powerful and effective strokes against the resistance of the atmosphere.

Digitized by Google

The structure and position of the flight-feathers play an important part in this process, since the two parts of the vane of a flight-feather are of unequal width, the anterior vane being much narrower than the posterior vane. Moreover, the flight-feathers do not lie close by the side of each other, but overlap each other in such a manner that all the anterior vanes come to lie on the upper surface, and all the posterior vanes on the under surface of the wing (something after the manner of the bars of a Venetian blind).

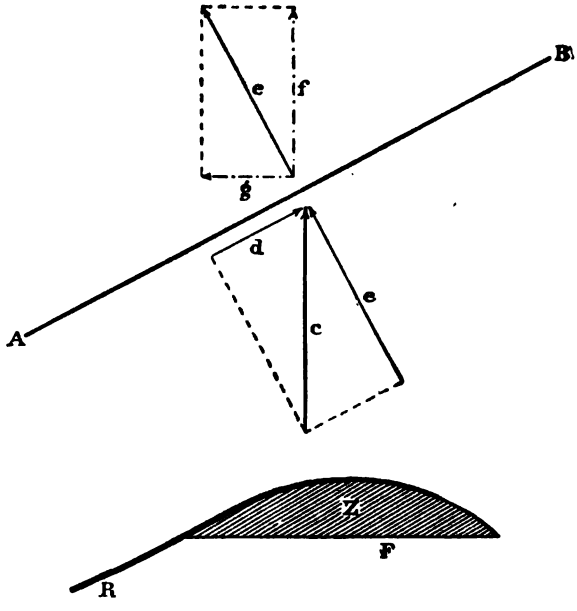
In the *downward* stroke of the wing the posterior vanes, in consequence of the pressure of the air thus produced, are applied so closely to the anterior vanes, which in part cover them, that the flight-feathers come to form an almost air-tight surface, *which prevents the passage of air.*

This is an absolute necessity for the downward stroke of the wing, but would have a damaging effect in the case of the upward stroke, in which the wings must encounter the least possible resistance of air, as otherwise each upward stroke would cause the bird to sink. To reduce this resistance to a minimum, the bird, during the upward stroke, bends the wing in the wrist-joint so that the hand (see Section 3), with its attached flight-feathers, is drawn almost vertically upwards. But even this movement does not sufficiently diminish the resistance of the air, and an additional one is called into play. In the upward stroke of the wing the air pressing on its upper surface strikes the narrow anterior vanes and the free-lying portions of the broad posterior vanes. These latter, being long and very flexible and unsupported below, and the whole feather being capable of a certain amount of rotation on its longitudinal axis, are accordingly *forced downwards, so that the air is enabled to effect a passage between the feathers.*

(*c*) *How does a bird progress in the air?*—In the downward stroke of the wings the elastic feathers are, by the pressure of the air, bent upwards to some extent, so that the wings form a surface inclined obliquely forwards and downwards (A B). Now, the stroke has the same effect as a current of air (*c*) striking against the surface of the wing from below. We are, in fact, dealing with a force impinging upon the lower surface of the wing at an oblique angle, and resolvable (according to the law of the resolution of forces) into two components, of which one (*d*) passes obliquely upwards towards the edge of the wing, and is without effect, whilst the second (*e*) strikes the surface of the wing at right angles to the first component (*d*). The component (*d*) alone is effectual in the forward movement of the bird; being itself resolvable into two components (drawn for the sake of clearness above the wing) (*g*) and (*f*), of which one (*g*) acts in a forward, the other (*f*) in an upward direction. By the first of these forces (*g*), accordingly, the bird is

Digitized by Google

impelled forwards; by the second (*f*) it is raised upwards, and hence prevented from falling. (Experiment: Construct according to the lower figure an *artificial wing* by means of a strong rod, R; a thread, F; and a piece of cloth, Z. If this apparatus is thrown with its surface vertically downwards, it will be found invariably to glide off forwards.)



(*d*) *How does a bird steer its course through the air?*—The tail, with its long tail-feathers (rectrices) forms (in addition to the wings) the rudder of our living air-ship. Inasmuch as the centre of gravity of a bird's body lies somewhat behind the shoulder-joint, a flying bird, by the mere use of its wings, would always assume a slanting position in the air, the posterior portion of the body being somewhat inclined downwards. By depressing the tail-feathers slightly downwards, however, they are forced upwards by the current of air impinging upon them in consequence of the flying movement, so that the body comes to assume a *horizontal* position. By depressing the rectrices *further* downwards the posterior portion of the body is still further elevated, the anterior portion being depressed, so that the bird now comes *to fly obliquely downwards.*

In ascending, the muscles of the tail relax their hold upon the tail-feathers, which thus come to lie in continuation with the longitudinal axis of the body. This causes the posterior portion of the body to sink downwards, whereby the bird is made to *rise obliquely upwards.* (Experiment: Take a child's paper-arrow and bend the end of it downwards. Now throw it horizontally, and it will at once fall to the ground in an oblique direction.)

When a bird flying in a direct line forwards wishes to wheel about to the right, it draws up the right wings to some extent, and strikes the air more forcibly with the left wing. This causes the left side of the body to be propelled further than the right, and the whole body accord-

Digitized by Google

ingly executes a *turn to the right.* (How is a turn to the left accomplished?)

12. **Organs of Sense.**—The speed with which birds move points to the possession of sharp-sighted eyes, equally adapted both for far and near vision. We need in this respect only consider the swallows as they rush along with the speed of an arrow, or song-birds searching for insects in the intricate meshwork of bushes and branches. The disproportionately large size of the eyes also indicates a sight of more than ordinary acuteness. In its essential features the eye is constructed on the same plan as in mammals (see Part I., p. 12), but besides the upper and lower eyelids it possesses a third eyelid, or *nictitating membrane,* which extends from the inner angle of the eye over its anterior surface like a transparent veil, and acts as a screen against light of too great intensity. From the fact that many birds are unsurpassed masters of song, it would seem that the *organ of hearing* is also well developed. There is, however, no external ear, or pinna (excepting in owls, which see). In this connection, too, we must not omit to mention the call and alarm notes used by many birds. The senses of *smell and taste* are extremely blunt. The bill and tongue function as *tactile organs.* (Compare the duck and snipe.)

13. **Reproduction and Care of the Brood.**—All birds propagate themselves by means of eggs, which, for the sake of protection against injury and excessive evaporation, are surrounded by a calcareous shell. Compare, on the other hand, the eggs of aquatic animals. Most birds build a nest of more or less artistic workmanship, in which the eggs are hatched by the heat of the body of the female or of both parents. (What birds lay their eggs on the bare earth? Which lays its eggs in the nests of other birds?)

Among the song-birds, the male tries to captivate the female by its song: it alone, accordingly, is capable of song. (Compare the lark and the nightingale.) The nests are constructed in many different ways: plaited together (swimming, wading and gallinaceous birds), woven together (golden oriole), felted (chaffinch), chiselled out or built (woodpeckers), walled-up or cemented together (house-martin), dug out or mined underground (sand-martin). (Give other examples.) The young are either helpless and dependent on parental nurture for a period after hatching (*aves altrices;* see pigeon) or independent from the moment of liberation from the egg—"precocious" (*aves præcoces;* see domestic fowl).

14. **Change of Habitat.**—Dearth of food and cold impel most of our birds, at the commencement of autumn, to migrate to countries further South (migratory birds, or migrants), their routes being determined by the courses of rivers, mountain passes, and ocean straits. They return

Digitized by Google

in spring to their old homes, sooner or later, according as they find, earlier or later, an abundant supply of food. (Observe the order in which our most familiar species migrate in spring and autumn. What birds are winter visitants only in this country?) Such birds as find sufficient food with us in the winter do not depart during this season. These either remain throughout the whole of the winter in their original home (residents), or they rove about the country, mostly in flocks, in search of food (birds of passage; give examples).

ORDER I.: BIRDS OF PREY (RAPTORES).

Upper mandible hooked at the end and overlapping the lower; at the base of the upper mandible, a cere (naked skin), surrounding the nostrils. Feet with large curved talons. Young helpless.

Family 1: Falcons (Falconidæ).

The Common Buzzard (*Buteo vulgaris*).

(Length from 20 to 24 inches.)

A. Name.

The name buzzard is derived from the German words *Buse*, which is equivalent to cat, inasmuch as the cry of the bird resembles the mewing of the latter animal, and *Aar* = *Adler*—Anglicè "eagle." Thus, buzzard denotes "cat-eagle." In Germany the present species is known as the "mice-buzzard," in allusion to the food of the animal, which consists principally of these injurious rodents.

B. Food.

About sixteen mice are consumed in a day, and as many as twenty, or even more, have been found in the crop and stomach of this bird. It also consumes hamsters, rats, and especially grasshoppers, and is not afraid of attacking the poisonous viper. Occasionally, during a severe winter, it may also seize upon a young deer, or a hare or partridge; but its great services as a destroyer of vermin during the summer far outbalance these exceptional depredations, and the buzzard ought, therefore, to be carefully *protected*. Indeed, it *performs in the fields the services of the cat in the house*. (Compare the two animals on the points discussed in Section D.)

C. Habitat.

The habitat of this bird is correlated with the nature of its food. It frequents by preference ploughed fields, rich grasslands and small woods,

Digitized by Google

where it can find abundant food for itself and its young. The *nest* is built out of sticks on the tops of lofty trees. It displays little artistic

COMMON BUZZARD AND NEST. (About one-tenth natural size.)

skill in its construction, for, being a strong bird, the buzzard is well able to defend its young, and is not obliged to hide them and their cradle from the intrusive attention of such nest-plunderers as magpies, jays, etc. (Compare it, on the other hand, with the nightingale and the chaffinch.) The *eggs* are greenish-white, spotted with brown.

D. Adaptation of the Body for a Predatory Mode of Life.

1. The buzzard may often be seen sitting on a tree or hill motionless, and apparently quite indifferent to its surroundings, but all the time looking out for prey, with its feathers puffed up. (The plumage in the young birds is of a lighter or darker brown; in old birds it is much spotted with white.) At other times it circles high in the air, surveying its hunting-grounds. In this manner the bird not only enlarges its range of vision (if we desire to get a wide view of surrounding country, we ascend a hill or tower), but also escapes the observation of the

Digitized by Google

animals which constitute its prey. Nothing, however, that passes on the surface escapes the keen eye of the bird. The acuteness of its vision may be gathered from the fact that even from the top of a high tower it can spy out so small an animal as a mouse, which, moreover, is further protected by the earthy colour of its skin.

2. The buzzard approaches its prey in rapid flight, or swoops down upon it head foremost with a rushing noise. To this end, the bird is provided with powerful wings, which, when expanded, measure about 45 inches from tip to tip. (Why must it be a rapid flyer? Many of its relations, however, surpass it in speed; see below.) When nearing the ground, it spreads its wings again, in order to check its velocity and alight without shock. (Observe a pigeon when it alights.)

3. It next proceeds to stop the prey from escaping, and to kill it. To this end, it seizes it firmly with its long and powerful toes, three of

BUZZARD SOARING.

which are directed forwards and one backwards, its long, curved claws, which are sharp and pointed as needles, piercing the body of its victim like daggers. These weapons are preserved against becoming blunt by balls under the toes, which prevent them from touching the ground when the bird alights.

4. The victim in its struggles may endeavour to defend itself, but its efforts are of little avail against a bird of the relative *size and strength* of the buzzard.

5. Its *feet* are protected against slight bites, the upper side of the toes and the anterior surface of the tarso-metatarsus being covered with *horny shields*. Moreover, the bites of its victim, which is confused by the wing strokes of its assailant, rarely strike the feet of the latter; as a rule, they only reach the feathers of the wing.

6. The prey is finally despatched by a few well-directed strokes of the

Digitized by Google

powerful beak. The upper half of this organ is curved from the root, sharply pointed at the end, and overhangs the lower half like a hook, constituting a formidable weapon, by means of which the buzzard can pierce the skull even of larger animals, such as hares or young deer. At the root of the upper bill is found a yellow membrane called the *cere.*

7. Prey of larger size is held fast with the feet, and *torn by means of the strong beak,* the hooked point of the upper beak being specially called into requisition for this purpose. Moreover, the sides of the upper beak also project beyond those of the lower, and, both having *sharp edges,* act like the blades of a pair of shears.

8. Small animals, such as mice, are *swallowed* whole; the *jaws* accordingly are wide, and the *œsophagus* and *stomach* very distensible. The stomach is thus thin-walled and sack-like, and not provided with powerful muscles like that of grain-eating birds (see pigeon), the food not being crushed up as in the latter, but dissolved by the acid juices of the stomach, as in a chemical retort. Indigestible materials, such as hairs, feathers, etc., are vomited in the form of pellets.

9. The *crop* is a dilatation of the œsophagus, in which the buzzard stores up such food as it cannot accommodate within the stomach.

Other Species of Falconidæ.

A number of species of this family are found in Central Europe, all of which resemble the common buzzard in their mode of life and structure of body. Its nearest relative is the **Honey Kite** (*Pernis apivorus*), which is of about the same size. The food of this bird consists chiefly of wasps, bees, and humble-bees. It seizes the formidable insect so skilfully that the sharp edges of its beak cut off a piece of the abdomen with the sting, which falls to the ground; for a sting in the mouth or gullet might be fatal to the bird.

THE COMMON KESTREL DURING FLIGHT.

The **Common Kestrel** (*Falco tinnunculus*) is of somewhat smaller size than the buzzard. Its plumage is rufous above, on the under

Digitized by Google

surface yellowish with dark brown longitudinal streaks. It builds its nest in old walls, towers, and high trees. Its food consists principally of insects which are injurious to agriculture (grasshoppers, mole-crickets), while it is also a zealous pursuer of mice. The bird therefore deserves protection rather than persecution.

Its larger and stronger cousin, the **Peregrine Falcon** (*F. peregrinus*), on the other hand, is often very injurious to human interests. It will even venture into large towns, in order to pursue pigeons. As it ranges almost all over the world, it has good right to its name.

The **Hobby** (*F. subbuteo*) is about equal to the kestrel in size, but is superior in powers of flight. It pursues even the rapid swallow, and to larks is the most deadly enemy.

The **Goshawk** (*Astur palumbarius*) and the **Sparrow-Hawk** (*Nisus communis*) will kill all animals of which they can obtain the mastery. The sparrow-hawk has to content itself with the smaller birds and mammals, but its larger and stronger relative, the goshawk, massacres birds of all sizes from the blackcock to the small song-birds, and all mammals from a young deer down to a weasel or mouse. Its impudent raids on our poultry-yards are well known. Both species are even more skilful flyers than the buzzard, and can capture a bird on the wing. The plumage in both species is ashy grey above; the under surface in adult males and old females is crossed by darker undulating streaks, and the tail is ornamented with dark transverse bars.

SPARROW-HAWK DURING FLIGHT.

The **Greenland Gyr-Falcon** (*Falco gyrfalco*), which breeds in high northern latitudes, was much trained by falconers for the capture of herons and pheasants.

The **Sea-Eagle** (*Pandion haliaëtus*) feeds exclusively on fish, and accordingly inhabits districts well supplied with water. It usually roves along close above the surface, and, if it descrys a prey, swoops down upon it with the speed of an arrow. Its plumage is on this account oily, and tightly fitted to the body. (Compare with kingfisher.) In seizing its prey, the outer toe is directed backwards. (Why?) The under surface of the toes is rough like a file, so that the most slippery fish cannot escape from its grip. The plumage is brown above; the head, neck, and under surface are white with many brown spots. The

Digitized by Google

sea-eagle is distributed almost over the whole earth. In places where the waters remain unfrozen throughout the year it is a resident; in other places it migrates south on the approach of winter.

The **Golden Eagle** (*Aquila chrysaëtus*) inhabits the mountains and large forests of Europe and Asia. Its size (over 3 feet), its handsome dark brown plumage, its bold, fiery eye, its powerful claws, and its majestic flights, extending to heights in which it appears a mere speck, fully entitle it to its designation as "king of the air." It is the symbol of strength and power, and as such figures in the coat of arms of many imperial and royal dynasties. The bird builds its nest on the summit of lofty trees or in the recesses of inaccessible cliffs. Its food consists of all kinds of birds and mammals. When pressed by hunger, it will even seize a lamb or kid under the very eye of the herdsman, carrying off its prey through the air in its powerful talons. Among the game it often makes greater havoc than the severest winter.

The Bearded Vulture, or Lammergeier (*Gypaëtus barbatus*).—This species occupies an intermediate position between the vultures and the falcons. In its short toes, with their blunted claws, and the strong beak, it resembles the vultures (which see), whilst the neck is covered with feathers, as in the falcons. It kills living animals (chamois, goats, etc.) by driving them down into abysses, but will also eat carrion. It was once widely distributed in the Alps, but is now almost exterminated. In the high mountain ranges of the countries bordering the Mediterranean, however, it is still frequently met with. The plumage is black on the back; the neck and under surface are rufous yellow. A beard-like tuft of feathers is found underneath the bill (hence the name bearded vulture).

Family 2: Vultures (Vulturidæ).

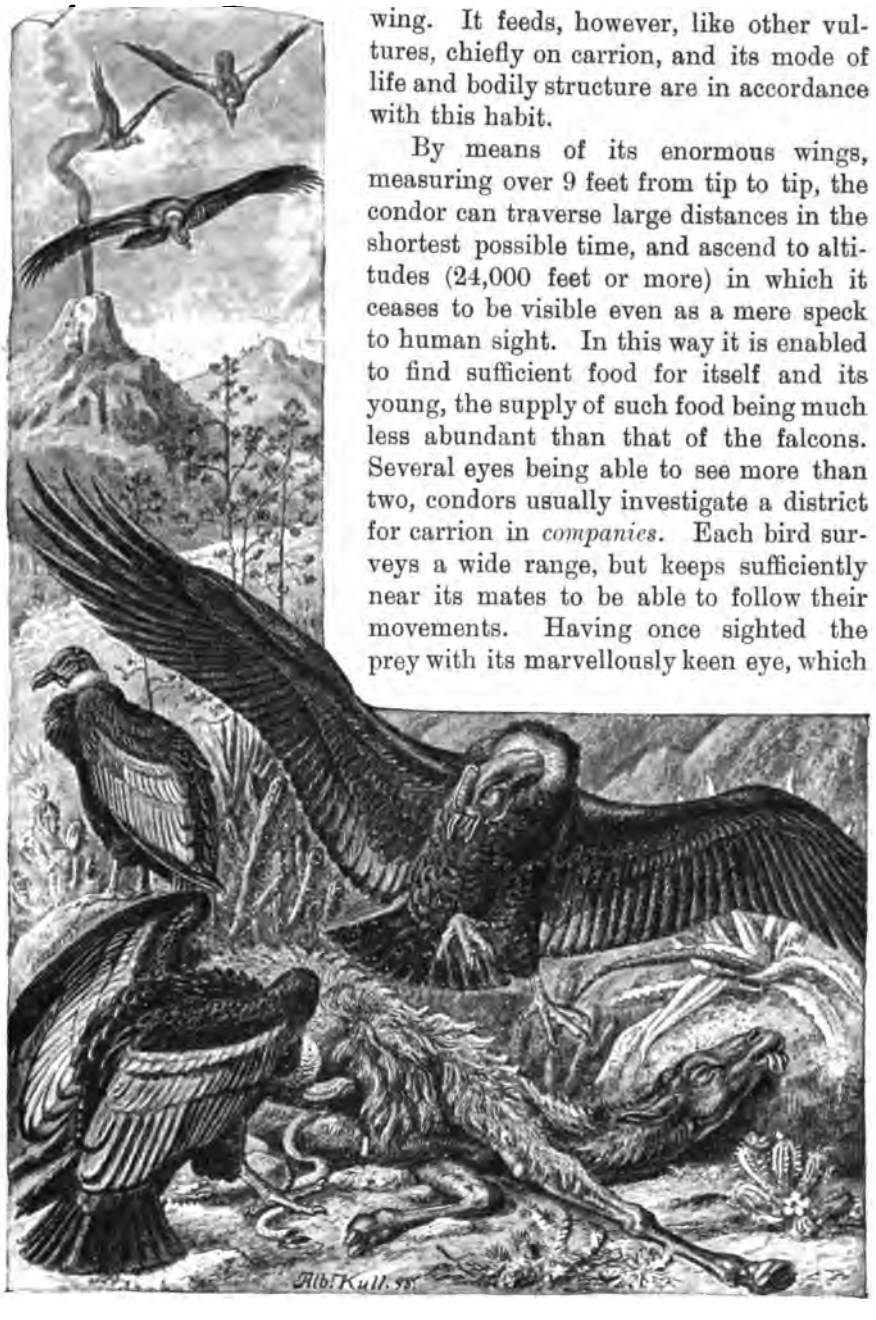
The Condor (*Sarcorhamphus gryphus*).

This gigantic bird, measuring over 3½ feet in length, inhabits the Andes of South America. Its plumage is black, with the exception of the large flight-feathers and the downy ruff, which are white. The head, which is naked, is blackish-grey, and the neck, also naked, of a fleshy-red colour. The male, like our domestic cock, has a red fleshy comb upon the root of the beak and the forehead. The condor is not a true raptorial bird; this is sufficiently indicated by its *feeble toes, the claws of which are short and blunt* (compare with buzzard). When pressed by hunger, it will attack larger living animals; but, being unable to seize them (like the falcons), it worries them to death—pushes them down precipices or inflicts mortal wounds on them with its beak while on the

Digitized by Google

wing. It feeds, however, like other vultures, chiefly on carrion, and its mode of life and bodily structure are in accordance with this habit.

By means of its enormous wings, measuring over 9 feet from tip to tip, the condor can traverse large distances in the shortest possible time, and ascend to altitudes (24,000 feet or more) in which it ceases to be visible even as a mere speck to human sight. In this way it is enabled to find sufficient food for itself and its young, the supply of such food being much less abundant than that of the falcons. Several eyes being able to see more than two, condors usually investigate a district for carrion in *companies*. Each bird surveys a wide range, but keeps sufficiently near its mates to be able to follow their movements. Having once sighted the prey with its marvellously keen eye, which



CONDOR. (The birds in the foreground about one-twentieth natural size).

Digitized by Google

may be aptly compared to a telescope, the bird at first descends in spiral curves, but finally swoops down to the ground with rushing speed. It is soon followed by its companions, to whom this downward rush is the signal that food of some sort or other has been sighted. The loathsome feast now begins. With a few thrusts of their *powerful beaks* the thick hide of the carcase—a dead horse or llama—is speedily torn open. The birds next thrust their long naked necks into the cavity of the animal's chest or belly. (Of what advantage are a long and bare neck to the birds?) The entrails and large pieces of the flesh are torn away with the *hooked end of the upper beak*, or cut away in shear-like fashion by *the sharp edges of the bill*. The separate portions are swallowed in huge lumps, bones and all. The *pharynx* and *œsophagus* of these animals are accordingly very wide, and the *gastric juices* very acid. Each of the birds devours as much as it possibly can on the spot, since (owing to the probable arrival of smaller carrion-feeders, and also rapidly ensuing putrefaction) there would be none of the meal left on the morrow, and it may be some days before another equally rich feast is provided. The *crop* and *proventriculus* are, therefore, also of unusually large size, the former, when filled, protruding from the neck like a sack. Having satiated their appetites, the birds, scarcely able to move, rest for a time. They then fly to the water, in order to drink and clean their blood-smeared feathers.

Vultures are only found in *warm or hot regions*, where carrion is always abundant. Those species which frequent towns and villages, by consuming, before they putrefy, dead animal carcases and all sorts of offal thrown into the streets, are highly useful to the inhabitants, acting, in fact, as *public scavengers or sanitary police*. (Compare the condor with the hyæna.)

Family 3: (Owls Strigidæ).

The Barn-Owl (*Strix flammea*).

(Length about 14 inches.)

A. Its Food and Importance to Man.

Like the buzzard, the barn-owl feeds only on live animals. Though among these must be classed the larger insects, shrew-mice, moles, and occasionally singing birds, its food consists chiefly of *mice;* so that it has been called, not without reason, "a flying cat." (Show also how it deserves this title in regard to its structure and manner of pursuing the prey according to the headings as given below.) The bird, therefore, is a valuable helpmate to man, which ought to be protected and preserved.

Digitized by Google

Unfortunately, it is usually the case that, while the four-footed cat is sheltered and protected, the owl is incessantly persecuted, and frequently even, in gross ignorance of its true habits, nailed to the barn door. Ignorant superstition alone is accountable for this treatment of the bird. Its strange shape; its habit of turning night into day; its noiseless, stealthy flight, as it passes, like a shadow, over the sleeping earth; its weird cry, which resembles the snore of a sleeping man — all these peculiarities have caused the owl to be regarded as a bird of ill-omen and a foreboder of misfortune. The owl is, in truth, a peculiar bird, but its peculiarities are not due to mere chance or accident, but are conditioned by its mode of life and habits. Let us therefore inquire how—

B. The Structure of its Body agrees with its Mode of Life.

i. It is a Predatory Creature.

Consequently we find it equipped with—

1. *The beak of a raptorial bird.* The upper mandible is less hooked, and therefore less adapted for tearing large prey.

2. *Feet of the raptorial pattern,* as in the buzzard (which see). The feet are, however, also adapted for climbing, since the outermost of the three anteriorly-placed and sharply-clawed toes is capable of being directed backward—reversible toe (see woodpecker).

3. It swallows its food whole or in large pieces; the organs of digestion are accordingly constructed like those of the buzzard. It also vomits the undigested portions of the food in the form of pellets.

ii. The Owl is a Nocturnal Bird of Prey.

1. It spends the day asleep in some safe hiding-place, such as a barn, a rock cavern, a church-tower, an old building, where it also breeds. Like all other cave-breeding birds, however, it never builds a proper nest. (Why is this unnecessary?) The eggs are pure white, not requiring any protective colouring, as in their dark recesses they are withdrawn from the notice of would-be plunderers. (Compare, on the other hand, the lark and the partridge.) Its *dusky* plumage renders it indistinguishable in its hiding-place, and quite unnoticeable at night. The colour is grey above, rufous below, with numerous white and brown arrowhead-shaped spots. Around the eyes and beak the feathers are arranged in the form of a heart-shaped disc (see Section ii. 4), or "veil" (hence in German called "veiled owl").

2. With the approach of night the owl is roused into action, this being the time when the mice abandon their nooks and crannies. With ghost-like silence the bird stealthily flies hither and thither, listening

Digitized by Google

and prying everywhere. The *eyes* are large and capable of receiving a large number of light-rays even at night, the pupils, moreover, being capable of dilating to a considerable extent. For near objects its sight is excellent. It flies accordingly only at an inconsiderable height above the ground, *both eyes, moreover, being directed forwards*, so that during flight they are turned towards the ground.

3. On pitch-dark nights, however, the owl is no more able to see than any other animal, and then relies only on its sense of *hearing*, which is of marvellous acuteness. Even when asleep the bird can hear the slightest noise, whilst during the pursuit of prey not the rustle of a mouse nor the quiver of a sleeping bird escapes its notice. While at rest the large apertures of the ears are closed by cutaneous flaps, or covers, which are turned forwards during flight. These covers act as receivers of sound, like the external ears (pinnæ) of mammals. Their surfaces are much increased by

HEAD OF BARN-OWL, WITH THE AURAL APERTURES UNCOVERED.

D, Ear-cover; O, aperture of the ear-passage.

4. *The feathers of the disc.* As, however, the sound-receiving flaps stand in front of the ear-openings, they must naturally convey to the ear chiefly the sound-waves coming from behind. The owl, therefore, generally hears the movement of its prey when it has flown past it; then it captures it with a sudden turn of its body.

5. Its silent, light-winged flight enables it to hear the slightest sound, and, moreover, prevents it from being heard by its prey. This noiseless flight is due to the thick, loose, *silky-soft plumage*. (Compare, on the other hand, the diurnal birds of prey, with their stiff plumage and rushing flight.)

Related Species.

The largest of the owl species, and the only really injurious member of the family, is the **Eagle-Owl** (*Bubo maximus*), which occurs but rarely in Britain. (In Germany it is known as the *Uhu*, from its weird peculiar cry, which has given rise to the legend of the "Wild Huntsman.") It inhabits large forests. The plumage bears the closest resemblance to the bark of old trees. The ears are surmounted by a tuft of erect

Digitized by Google

feathers. (What is the probable significance of these tufts?) It devours all kinds of game, attacking even the fawns of roe and red deer; but its food consists principally of mice, frogs and all kinds of birds. Its finely-pointed claws can even penetrate the prickly skin of the hedgehog. It is the sworn foe of all other birds, for which reason it is used in the rook-shooter's hut as a decoy for birds of prey.

The **Little Owl** (*Athene noctua*) is fond of orchards, but also lives in towers, garrets, and old walls. The plumage is brown on the back, with many white spots; the under side is white, with brown spots. The apertures of the ear are very small, and the disc correspondingly indistinct (explain why); the bird is accordingly less nocturnal in its habits than the barn-owl. Even before sunset it begins to seek food, which consists of insects, small mammals, and birds. Its cry sounds like "coo-ee-meet," which resembles the German *komm mit* (Anglicè, "come along with us"); and superstitious people in Germany imagine that the bird is inviting sick people to accompany it to the churchyard, for which reason it is also known in that country as the "funeral" or "death" owl.

ORDER II.: WOODPECKERS (PICI).

BEAK straight, long, and chisel-shaped. Tongue thin and protrusible. Feet "scansorial" (*i.e.*, adapted for climbing). Young helpless (*altrices*).

The Great Spotted Woodpecker (*Dendrocopus major*).

(Length 10 inches.)

A. Origin of Name.

This handsome bird derives its name from its multicoloured plumage (head and neck spotted black and white; back and wings black, with white spots and stripes; belly yellowish-grey, passing into crimson towards the tail; the male with a red spot on the occiput). The designation "great" is to distinguish it from the Lesser Spotted Woodpecker, which much resembles it in coloration, structure, and mode of life.

B. An Inhabitant of the Forest, and exclusively Arboreal in Habits.

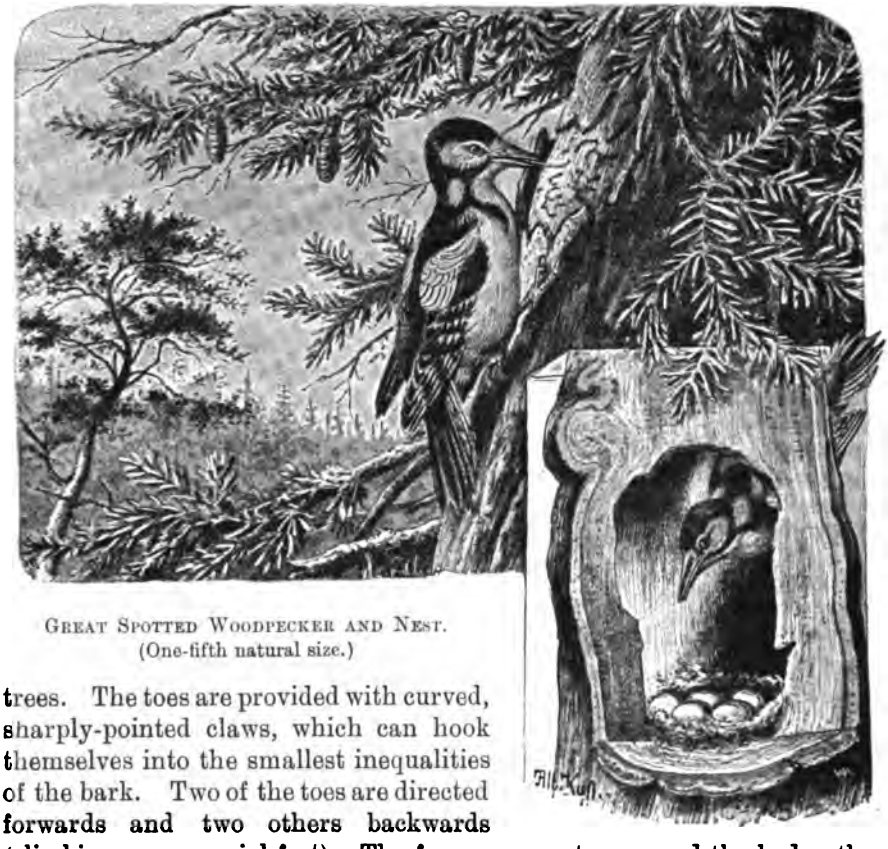
i. The Trees provide it with Food.

This consists of all kinds of insects and insects' larvæ which burrow in the bark and wood of trees. It is specially fond of the bark-beetle and its larvæ and eggs, and for this reason frequents by preference pine

Digitized by Google

and fir woods. It also industriously searches for all kinds of insects in the cracks and furrows of the bark, and when they are ripe feeds on the seeds of fir-cones. Let us now examine how the bird is adapted for obtaining food of this kind, and more especially insects living under the bark or in the wood of trees.

1. *Its feet* are specially adapted for holding on to the trunks of



GREAT SPOTTED WOODPECKER AND NEST.
(One-fifth natural size.)

trees. The toes are provided with curved, sharply-pointed claws, which can hook themselves into the smallest inequalities of the bark. Two of the toes are directed forwards and two others backwards (climbing or scansorial feet). The former serve to suspend the body; the latter support it and prevent it from slipping down. Three of the toes being very long, the bird is enabled to embrace a large surface with its feet.

2. Owing to the shortness of the *leg* (tarso-metatarsus) and the narrowness of the *sternal keel*, the woodpecker sits with its body pressed close to the trunk. This renders its seat safer, since the centre of gravity of the body comes to lie *above*—

3. *The tail*, the feathers of which terminate in stiff-pointed ends, which are propped against the ridges and rugosities of the bark. The

Digitized by Google

tail and feet form, in fact, a tripod, on which the bird sits safely even upon a vertical tree-trunk, and it can actually sleep in this position. The support afforded by the roof-like tail is due to the following characters:

(1) The quills of the tail-feathers are very strong and hard.

(2) The tail-feathers of each side lie one above the other, and not by the side of each other, hence they mutually support each other (acting, in fact, like a single pair of very strong feathers).

(3) The vanes of the tail-feathers are of equal breadth on both sides, narrowing at the tip, *and their barbs are very stiff and inclined downwards.*

The woodpecker ascends trees by hopping (simultaneously with both feet) up the trunks in short leaps or in spiral lines, at the same time moving its wings forwards by jerks. (In jumping over a ditch we thrust our arms forwards. Why cannot the woodpecker move along the trunk from above downwards?) During its ascent the bird incessantly taps the tree with its beak, immediately after each tap running over to the opposite side of the trunk. By this tapping it alarms the insects, who abandon one side of the tree to escape their enemy, and run straight "into his arms" on the other side. The tapping of the woodpecker's beak makes a noise which can be heard from a great distance in the woods.

4. By means of powerful blows with its long, straight, wedge-shaped *beak*, which is covered with a solid layer of horn, the woodpecker gets at the insects underneath the bark or within the wood. The upper mandible is especially powerful, being further strengthened by three longitudinal ridges of horn. It projects slightly beyond the under bill, and does not terminate in a point, but in a vertical, chisel-shaped, cutting edge. By means of this excellent implement the bird not only peels off the bark, but chips off the hard wood in splinters, whence it has not without reason been called "the carpenter of the woods." In connection with these peculiarities we must consider the following additional facts:

(*a*) The *neck* being short enables the bird to deal well-directed blows. (If we wish to deal a safe blow, we grasp the hatchet near the head.)

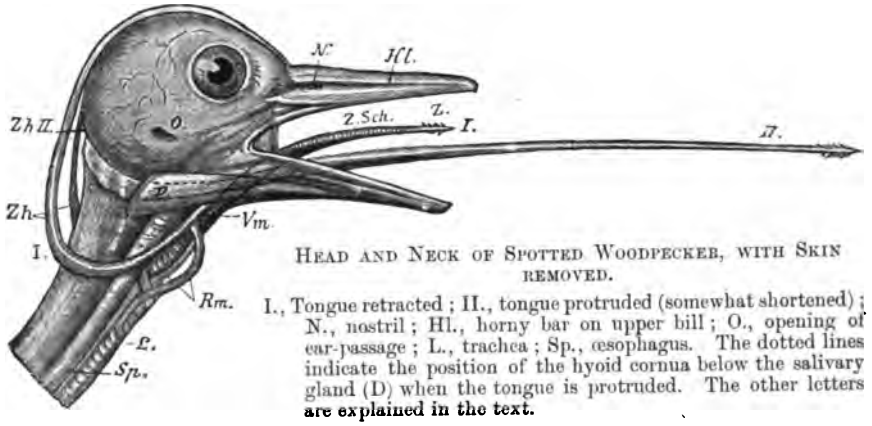
(*b*) In taking aim for a blow, the woodpecker presses its tail against the trunk of the tree, the fore-part of its body being bent backwards. This has the effect of bending still more the *quills of the tail-feathers*, which (during rest) are to some extent curved upwards. With the cessation of the pressure, the feathers rebound like springs into their original position. They thus force the hinder end of the body away from the tree-trunk, and the fore-part towards it, so increasing the force of the stroke.

(*c*) The head, being relatively *large and heavy*, also aids in augmenting the effects of the blows inflicted by the beak. (To deal a heavy blow, we use a heavy hammer.)

Digitized by Google

(*d*) The *strong bones of the skull* afford a firm support to the chisel-like action of the beak, and are capable of withstanding powerful shocks.

5. The insects are pulled out of their crevices and galleries by means of the peculiarly-constructed lingual apparatus. The tongue itself (Z.) is small, horny, and provided with a few sharp barbs on each side at its tip. Posteriorly it is united with a rod-shaped bone, the hyoid. The latter lies within a muscular sheath (Z.Sch.), which when at rest is contracted in vermiform fashion, and at its posterior end is connected with two other bones, the hyoid cornua (Zh). These are very flexible, and extend from behind forwards over the occiput to the base of the beak, sliding freely in a muscular sheath, which is attached at the point of union of the rami of the mandible (Vm.). By the contraction of this muscle (shown in the form of folds below Zh II.) the horns are drawn



HEAD AND NECK OF SPOTTED WOODPECKER, WITH SKIN REMOVED.

I., Tongue retracted; II., tongue protruded (somewhat shortened); N., nostril; Hl., horny bar on upper bill; O., opening of ear-passage; L., trachea; Sp., œsophagus. The dotted lines indicate the position of the hyoid cornua below the salivary gland (D) when the tongue is protruded. The other letters are explained in the text.

down towards the nape of the neck (their ends coming to lie at Zh II.), and push the hyoid bone forwards. This has the effect of extending the vermiform sheath of the hyoid into a smooth cylinder (like an earth-worm when extended), and the tongue is consequently protruded far forwards from the beak. (Compare with the tongue of humming-birds, chameleon, and snakes.) On account of its extraordinary length, thinness, and eel-like flexibility, the organ penetrates with ease into the borings of grubs and can even follow their windings. The larger insects are pierced by the horny tip of the tongue (really forming a barbed arrow-head); the smaller are, as it were, glued on to the tongue by a very viscid saliva, which is abundantly secreted by large salivary glands (D). The tongue is always completely smeared over with this fluid, so that insects stick to it like "flies to a limestick." The tongue is retracted by the muscles of the sheath (Z.Sch.) and several other muscles, some of which (Rm.) are indicated in the illustration.

Digitized by Google

6. It is interesting to inquire by what means the bird becomes aware of the existence of insects or their larvæ in the interior of the tree.* It may discover this by means of its eyes (by the worm-holes), or the tappings of the beak may convey some notion of it to the *ear*. (We can tell by tapping a barrel whether it is empty or full.) It is possible, too, that the sense of *smell* may give it some indication of the presence of its prey. (We ourselves recognise the presence of several insects by our smell. Give examples.) It is, however, a well-ascertained fact that the tongue of the woodpecker is excellently adapted as a *tactile* organ.

ii. Trees provide both its Breeding-place and its Resting-place at Night.

With its beak the woodpecker hollows out its nest in the trunk of the tree, always high above the ground. (Why?) It first chisels out a horizontal passage only sufficiently wide to allow it to slip through (why is it so narrow?), and then excavates the nest-hole, which passes down vertically into the stem. The eggs, which are white (see barn-owl), and incubated alternately by both parents, are laid on chips or powdered wood at the bottom. A similar hole forms the bird's sleeping chamber at night.

C. Place of the Woodpecker in the Economy of Nature, and its Importance to Man.

From the mere fact that the woodpecker consumes daily large quantities of injurious insects, we may gather its great importance to the forest and to those concerned with its preservation. Naturalists who have carefully studied the life and habits of this bird call it "the real preserver of our forests." It has been condemned for chipping and mutilating the trees; but it is just for this very act that it deserves the gratitude of the forester, since no other ánimal is able to the same extent to kill off wood-boring insects, and thus effectually check the increase of these destroyers of our forests. Indeed, the woodpecker never attacks sound trees, since these would furnish no food, but only such as are infested by insect pests. In this way the bird points out to the forester what trees are to be cut down before they are destroyed beyond all hope of being of further use; and though it hews out its holes for its own benefit, these at the same time form most suitable breeding-places for many song-birds (starlings, tits, redstarts, which are themselves active insect-destroyers). The woodpecker accordingly is doubly deserving of protection; nor ought we to grudge the bird the small tribute it takes

* It is extremely difficult to form a correct judgment on the perceptions of an animal. (Why?) We are invariably tempted to draw comparisons, which may be very erroneous, from our own senses.

Digitized by Google

for its services in the shape of the seeds of pine and fir trees, for do we not also pay country labourers for collecting and destroying the insects which devastate our woods ?

Related Species.

The **Lesser Spotted Woodpecker** (*D. minor*) has been already referred to. The **Great Black Woodpecker** (*Dryocopus martius*) is the largest of the European species (length 18 inches). Its plumage is black, with the exception of a red spot on the head. It is not a native of Britain. The **Green Woodpecker** (*Picus viridis*) is not a true forest bird, but prefers districts where small woods alternate with fields and meadowlands. Its favourite food consists of ants, which it catches with its long, sticky tongue. For this reason also it frequents the ground, the green tints predominating in the colour of its plumage (describe this more fully), here serving it as good protection against goshawks and sparrow-hawks. A more distant relative of the woodpeckers is the **Wryneck** (*Iÿnx torquilla*). Though possessed of "scansorial" feet, the bird can only use them for holding on to the trunks of trees, its soft and flexible tail-feathers not affording it any assistance in climbing. The beak is weak, and not adapted for chipping. Its food, therefore, mainly consists of ants; these it catches on the ground or on tree-trunks, by means of its vermiform, slimy tongue. Its plumage exactly resembles the colour of bark and the soil. When surprised by an enemy, the bird resorts to all kinds of curious performances (protective), by which it endeavours to frighten its captor: it erects the feathers of its head, spreads out its tail and wings, rolls its eyes, stretches forth its long neck, and twists its head like a snake, at the same time widely opening its bill and hissing like a viper.

ORDER III.: CUCULINE BIRDS (COCCYGOMORPHÆ).

Beak usually long. The tongue short and flat. The feet are of the climbing or perching type, often with one or two reversible toes. Young helpless.

The Cuckoo (*Cuculus canorus*).

Old and young rejoice when the note of the cuckoo once more resounds in the wood, for then we know that the stern rule of winter is at an end. To be sure, we rarely get sight of the bird, for it is very shy. It is about *the size of a dove*. The plumage is ash grey above, greyish-white with many black transverse bars on the under

Digitized by Google

surface. Thus it bears a strong resemblance to the sparrow-hawk (see p. 157), and, according to a popular belief, the bird in autumn changes into a sparrow-hawk, and back to a cuckoo in spring. One of the three anterior toes can be turned backwards (reversible toe), so that the bird is able to maintain an equally firm hold on thick and on thin branches. With its *bill*, which is small and slightly curved (compare with nightingale), it picks up all kinds of insects, but its principal food consists of the long-haired caterpillars of the Processional Moth, the Pine-tree Lappet Moth, and the Black Arches Moth, which are the most destructive insects of forests, and are rejected by almost all other birds on account of their hairy covering. Hence the great usefulness of the cuckoo, which destroys incredible quantities of these insects; for the bird is constantly in motion (which entails a great expenditure of energy), and, moreover, these caterpillars are by no means such fat morsels as they appear to be (on account of their hairs and the vegetable contents of their intestine). The mouth is very wide and *distensible*, enabling the bird to swallow the largest caterpillars, of which a considerable number can be accommodated in its large *dilatable* stomach. The inner surface of the stomach is often completely lined, as with a fur, by the hairs from the bodies of these caterpillars. The cuckoo is a migratory bird.

The most interesting fact in connection with this peculiar bird is that it never builds a nest of its own, *but foists its eggs upon other birds*. Even before laying a single egg, the female seeks out a suitable nest of a song-bird, a finch, a lark, etc. It then deposits its own egg by the side of those already in the nest, and leaves the task of hatching it to the proper owner of the nest. If the nest is placed in such a position as to be inaccessible to a bird of its large size, it deposits its egg on the ground, places it in its mouth, and carries it up to the nest. Though the song-bird frequently abandons its nest after seeing the strange egg, in most cases it does not notice it, the egg of the cuckoo being extremely small, and in colour often resembling that of the song-bird upon which it has been foisted. As, however, the eggs are exposed to many vicissitudes in strange nests, the cuckoo lays a large number—twenty or more—one after the other. This it is able to do so much the easier, as, not having to look after its young, it takes food in abundance at a time when other birds occupied in breeding can only with difficulty obtain sufficient (why?). Its offspring is reared and fed with small caterpillars by the foster-parents along with their own progeny. Gradually the young intruder grows to such a size that it requires more room. It then pushes its foster-brethren out of the nest, and finally, having become fledged, leaves its foster-parents for ever.

Digitized by Google

Related Species.

The **Kingfisher** (*Alcedo ispida*) *is one of the handsomest of our native birds.* On its upper side the predominating colour is a brilliant metallic blue, on the under side a rich orange-rufous with silky sheen. The chin and throat are white, and the feet brick red; the bill is black. As its *food* consists of fish, crabs, and aquatic insects, it lives *near the water.* Its small *feet* are not adapted for walking, but only for sitting (perching or passerine type). For hours long the bird sits motionless on a branch close above the surface of the water in wait for its prey, "like a cat for a mouse." As soon as its sharp eye has discovered a fish, the bird dives head foremost into the water (the head is wedge-shaped). Having seized its scaly victim in its *large, sharp-edged* beak, it reaches the surface by means of a few strokes with its *short wings* and resumes its former seat. The fish being by this time dead from suffocation, or killed by being knocked against a branch, the bird next forces it head foremost (why?) down its *wide throat.* As the kingfisher fetches its food out of the water, its plumage is stiff, tightly fitted to the body, and extremely oily (compare with duck). On account of its *small size* (7½ inches), it can only capture small animals, but as it is extremely voracious it destroys large numbers of fish. When the streams have become turbid from prolonged rains, the bird often suffers from want of food (why?), as is also the case in severe winters, when the streams are covered with ice, and only a few spots remain open for fishing in. The birds, with their strong beaks, bore for themselves in steep (why?) banks narrow passages or tunnels, which terminate in a chamber (breeding chamber), in which the *white eggs* are laid (see owl) upon cast-up fish-bones and other rubbish.

The **Hoopoe** (*Upupa epops*) frequents pastures by preference, its favourite food consisting of all kinds of dung-burrowing insects and their larvæ. With its long, soft and slender bill it pulls its food out of the dung, or from under stones, etc., and also digs up worms and larvæ out of the soft soil (see snipe). Its *tongue* being *too short* to convey the food to the mouth, the bird throws it up in the air and catches it in its widely-opened bill. It is a migrant. The feet are strong, and well adapted for continuous walking (compare with kingfisher). The general colour of the *plumage* is light brown, passing into white on the belly. The wings and tail are black, transversely banded with white. The head bears a crest of feathers, which the bird can unfold like a fan. On the approach of any danger the bird squats on the ground, spreads its wings and tail, holds its beak aloft, resembling in this position a coloured rag rather than a bird, and remains motionless in this *protective pose* until

Digitized by Google

the danger is past. During the breeding season the uropygial gland of the female secretes a very evil-smelling fluid, and as the old birds, moreover, do not remove the droppings of the young, the nest usually gives out a most disgusting stench. Hence its popular name in Germany, "stink-bird."

ORDER IV.: PARROTS (PSITTACI).

THE upper mandible is less in length than in height, and very movably articulated with the frontal bone. The lower mandible short and broad. The tongue thick and fleshy. Feet "scansorial." Young helpless.

The parrots, with few exceptions, are inhabitants of the *tropical zone*. None are therefore found in Europe, though they occur in all the other continents. The majority inhabit primeval forests, but some frequent barren steppes, while others even ascend lofty mountain-ranges (Andes of South America) far above the limit of trees. *The numerous species of parrots differ considerably in their mode of life and habits.* This is a natural consequence of the fact that they live under different natural conditions, in so far as the conditions prevailing in the aboriginal forests of one country or continent are unlike those of another. (Compare, for instance, the forests along the Amazon with the Australian Bush.) We shall therefore here confine ourselves to the consideration of the parrots of one particular region, viz., the tropical forests of South America.

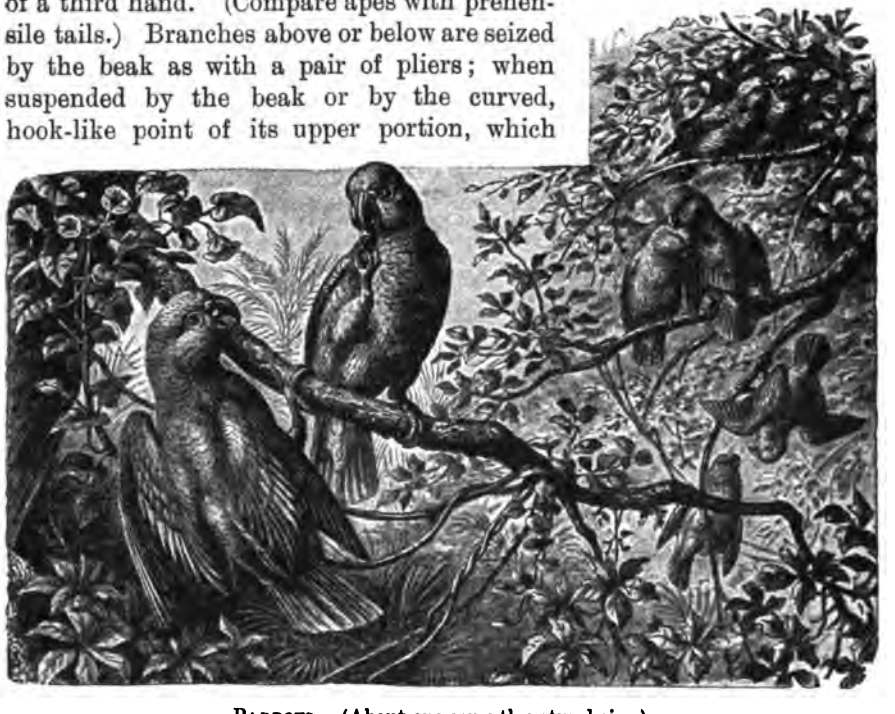
i. Plumage.

Green is the predominant colour, and by rendering the birds almost invisible in the dense crowns of the giant trees of these forests, with their evergreen foliage, serves as an effective protection from their enemies. (When would a green plumage be extremely dangerous to the birds of an English wood or European forest? Compare with nightingale.) Nor are these birds rendered conspicuous by the red, blue, yellow, or white colour which usually adorns some part of their plumage, since many of these forest trees bear throughout the whole year large many-coloured blossoms. Their branches, moreover, are usually covered with the gay-coloured blossoms of numerous parasitic plants (*e.g.*, orchids), while their crowns are interlaced by numbers of climbing and twining plants, which also produce bright-coloured flowers. Moreover, in many of these birds the coloured portions of the plumage are covered by the inconspicuously green-coloured wings, and only become visible during flight.

Digitized by Google

ii. They are Adept Climbers.

Flight is much impeded in the dense crowns of trees. Hence, parrots move about mostly by climbing from branch to branch. Their feet, like those of woodpeckers (which see), are constructed on the *scansorial* type, and enable them to clasp the branches with firmness and surety, though they are poorly adapted for hopping or walking. In climbing, the *beaks* render excellent service, performing, in fact, the functions of a third hand. (Compare apes with prehensile tails.) Branches above or below are seized by the beak as with a pair of pliers; when suspended by the beak or by the curved, hook-like point of its upper portion, which



PARROTS. (About one-seventh natural size.)
On the left two Amazon Parrots; on the right several Love-birds.

projects considerably beyond the lower, the bird can swing freely in the air. Friction is increased and a firmer hold insured by file-like notches on the under surface of the terminal hook of the beak. The upper mandible being united by a flexible joint to the frontal bone of the skull, parrots can open their beaks very widely, and therefore clasp branches of some thickness. They are, in fact, thorough experts in all sorts of climbing performances, and therefore have not without reason been named "feathered monkeys."

Digitized by Google

iii. Food.

Their food consists principally of fruits and all kinds of seeds, which the primeval forest supplies in inexhaustible abundance. With their powerful *beaks*, which they use like nut-crackers, they can crush the hardest shells and get at the sweet kernel within. The "file-like notches" above referred to render them good service in feeding, and more especially in the consumption of small, smooth-peeled fruits. The thick, fleshy, and highly movable *tongue* renders aid in the peeling of seeds, as may be seen by watching a tame parrot eating hemp seed. With larger objects (ears of corn, larger fruits) the *feet*, too, are called into requisition, for the purpose of holding the object and conveying it to the bill.

iv. Relations to Man.

Though parrots naturally cannot inflict any damage in their primeval forests, they may make sad havoc in the fields and fruit-gardens of settlers, which they often invade in great flocks. On account of their magnificent plumage, their affection for their keepers, their faculty of imitating spoken words and whole sentences, they are included among our most favourite cage-birds.

The **Green Amazon Parrot** (*Chrysotis amazonica*), a very intelligent bird, comes from the tropical forests of America. Our best talker is the **Gray Parrot** (*Psittacus erithacus*), whose native home is in Africa. The **Cockatoos** (*Cacatuidæ*) have a light-coloured plumage (see Birds of Paradise), and are distinguished by an erectile crest of feathers on the head. They are confined to Australia and the East Indian Archipelago. The neat little **Love-Birds** (*Psittacula passerina*) are usually kept in pairs on account of the great affection they show for each other. (In Germany they are known by the name of "inseparables.")

ORDER V.: SWIFT-LIKE BIRDS (CYPSELOMORPHÆ).

Bill broad and short, or slender and long; wings very long; legs very short, with naked, or incompletely cornified skin. Unable to climb, hop, or run, but excellent fliers. Young helpless.

The Common Swift (*Cypselus apus*).

This bird is a common species in Britain and Europe, and in size, structure, and mode of life strongly resembles the swallows (which see). (The plumage is brown with the exception of the throat, which is white.) It does not make its appearance (in Britain) until the end of April or

Digitized by Google

beginning of May, and departs again in August. It is a very active bird, a true denizen of the air, darting about from early dawn to late dusk at immeasurable heights or close above the ground or the water. (The wings are very long and sickle-shaped, and the tail deeply notched.) Its food consists of small insects, which it captures on the wing. (The beak is short, but the gape of the mouth extends as far as under the eyes.) It never descends voluntarily to the ground, its weak legs neither permitting it to walk nor to hop. By means of its sharply-clawed toes, however, all of which are directed forwards (clinging feet), it manages to hook itself on to walls and palings. The nest is a rough structure of straws, feathers, and poplar catkins, snatched by the bird while on the wing, and cemented together by a sticky saliva. It is usually placed in the crevice of a wall or cliff or in the hole of a tree.

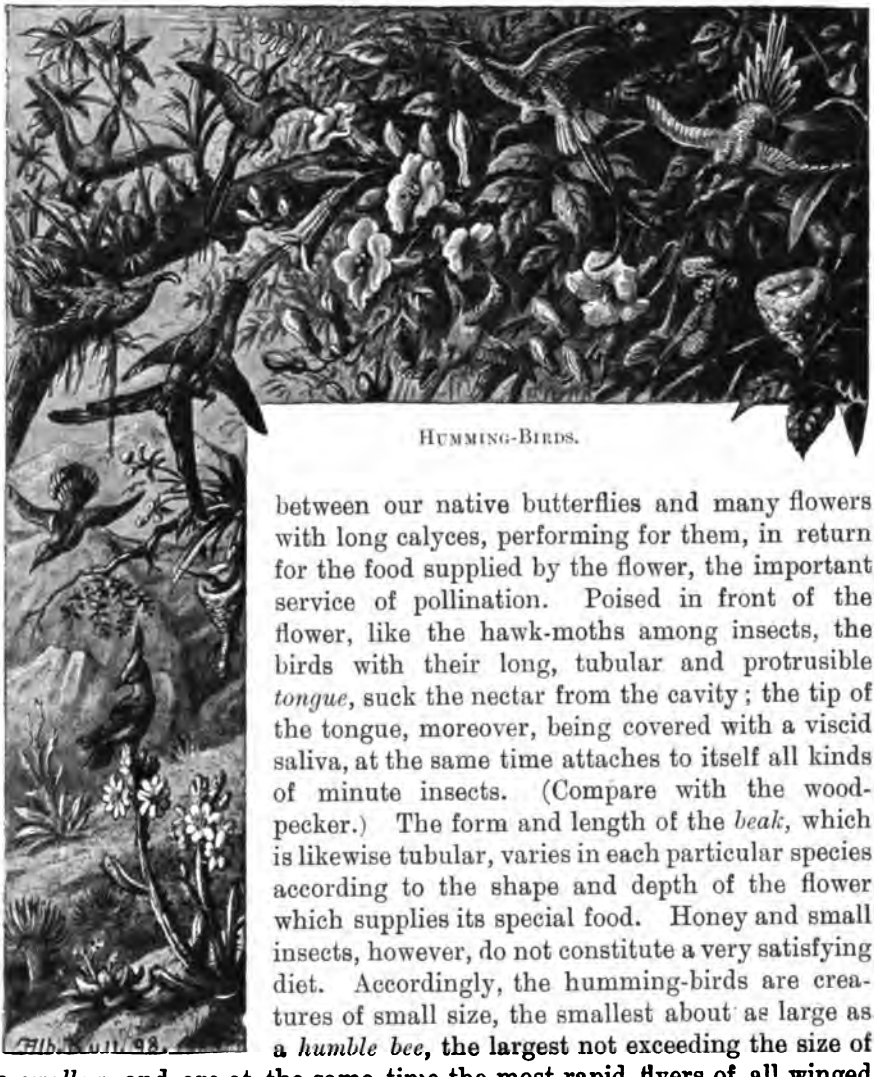
The **Salanganes** (*Collocalia*) are birds which closely resemble the swifts. They construct basin-shaped nests from a viscid indiarubber-like saliva, which rapidly hardens in the air. These nests are introduced into commerce as "edible swallows' nests." The home of these birds is in the East Indian Islands.

The **Common Nightjar** or **Goatsucker** (*Caprimulgus europæus*) is nocturnal in its habits, like the owl (which see), and insectivorous, capturing its prey on the wing, like the swallow (which see). Hence, in the structure of its body the bird bears resemblances to both these species. Its plumage, like that of the owl, is uncommonly soft, which renders the flight of the bird noiseless, while the wings, like those of the swallow, are long and pointed, and adapt it for nimble and rapid flight. (Why are both these conditions necessary?) Its large eyes and acute hearing enable it, like the owl, to hunt at dusk and in the dark. Being of larger size than the swallow (about the size of a blackbird), a diet of gnats and flies would not satisfy its needs. Its food, in fact, consists of large beetles and, preferably, moths. Its beak, however, is too small to grasp insects of this size, whence the gape of the mouth extends as far as under the eyes, and the throat is very wide. The oral opening is further considerably enlarged by the presence of bristle-like feathers (*vibrissæ*) at the upper edge of the large mouth, which is used after the fashion of a butterfly-net. The bird is almost incapable of walking on account of its weak feet (see swallow). When at rest, it lies flat on the ground or upon a branch lengthwise, its short toes not allowing it to clasp the latter. In this position, or when sitting on its brood, the bird cannot be distinguished from a piece of bark or the dry leaves which cover the soil, on account of the dull colour of its plumage, which is grey and brown, with darker and lighter stripes, spots, and undulating lines (compare owl). Though in many ways a very peculiar

Digitized by Google

bird, there is no justification whatever for the name "goatsucker" which has been applied to it. It is a migrant.

The **Humming-Birds** (*Trochilidæ*) exhibit in regard to the numerous plants of tropical America the same intimate relation which exists



HUMMING-BIRDS.

between our native butterflies and many flowers with long calyces, performing for them, in return for the food supplied by the flower, the important service of pollination. Poised in front of the flower, like the hawk-moths among insects, the birds with their long, tubular and protrusible *tongue*, suck the nectar from the cavity; the tip of the tongue, moreover, being covered with a viscid saliva, at the same time attaches to itself all kinds of minute insects. (Compare with the woodpecker.) The form and length of the *beak*, which is likewise tubular, varies in each particular species according to the shape and depth of the flower which supplies its special food. Honey and small insects, however, do not constitute a very satisfying diet. Accordingly, the humming-birds are creatures of small size, the smallest about as large as a *humble bee*, the largest not exceeding the size of a *swallow*, and are at the same time the most rapid flyers of all winged creatures. (They have long pointed *wings;* compare with swallow.) Their life being absolutely dependent on flowers, their habitat is restricted to regions where there is no cessation in the growth of flowering plants.

Digitized by Google

Their *plumage* is resplendent with the most brilliant colours, resembling the flowers around which they sport (compare with parrots), and accordingly these butterflies of the bird-world rightly deserve the title of "living gems." (Compare the humming-bird with a butterfly.)

ORDER VI.: SONG-BIRDS (OSCINES).

Legs unfeathered, invariably covered with fairly large horny plates, which frequently unite to form a so-called "boot." Foot with three anterior and one posterior toes; the two outer toes united at the base of the first phalanx (adapted for hopping). Lower larynx (see p. 147) highly developed, the majority of the birds in this order being in consequence capable of giving utterance to tuneful song. Young helpless.

Family 1: Finches (Fringillidæ).

The Chaffinch (*Fringilla cœlebs*).

(Length 6 inches.)

With the return of warm sunshine after a long winter, the melodious *notes* of the chaffinch are among the first to be heard in garden, grove, or wood. (It must be noted that the tune of the chaffinch is very variable.) The male is a very *handsome* bird. The forehead is black, the back of the neck slaty blue, the back brown, and the rump of greenish colour; the breast is of a rich red, and the wings are black with a white and a yellow transverse band. In the female the colours are duller, which is of advantage to the bird, for while sitting on the nest its inconspicuous colouring approximates it to that of its surroundings, so that it is easily overlooked by its enemies. (Similar differences in the coloration of the plumage occur in a large number of song-birds. Give examples.) The *nest* is spherical, and displays marvellous skill in its structure. It is suspended in the fork of a tree close to the trunk, and consists of a feltwork of moss and fine stalks of grass. With the aid of spiders' webs and other filaments, the outer wall is covered with lichens peculiar to the tree in which the nest is placed. In this way the little cradle assumes a striking resemblance to a weathered, lichen-covered tree-stump. Inside it is lined with a soft, warm padding of feathers, hair, and wool. The *eggs* are bluish-green, dotted over with black and brown spots, and are not easily distinguished from a distance (protective colouring). The plumage of the young—nestling plumage—is inconspicuous. Their *food*, like that of the old birds during the breeding season, consists of insects. Later, however, they feed prin-

Digitized by Google

cipally on the seeds of forest-trees, and especially of weeds. The *beak* is short, thick, and conical, and has sharp edges; it is therefore well adapted for removing the husks of seeds. Being largely restricted to the

CHAFFINCHES. (Three-eighths natural size.)

ground in the search for food, the *feet* of the finch are strong and excellently adapted for hopping. (Compare, on the other hand, the swallow.) At the end of the breeding season the birds collect in flocks and *rove* about the country. At the end of October they depart for their

Digitized by Google

winter quarters in the South of Europe. A few only, chiefly males, remain during the winter, subsisting on the few scanty remains of the rich summer season.

Allied Species.

The Goldfinch (*Fr. carduelis*).—This bird is a favourite domestic pet, on account of its intelligence and elegant plumage. (What legend is there relating to the latter?) Its food consists principally of thistles (in Germany one of its names is "thistle-finch"), hence it avoids the larger woods, and remains with us throughout the winter. The German name for this bird, *Stieglitz*, is derived from its call-note, which sounds somewhat like "steeg-ĕ-leets." The moderately long, pointed bill is well adapted for picking off thistle-seeds. The large stout bill of the Hawfinch (*Coccothraustes vulgaris*), on the other hand, is excellently fitted for opening hard seeds, cherry kernels, beech mast and the like.

The **Greenfinch** (*Fr. chloris*) is a familiar inhabitant of gardens and bushy localities. It lives on all sorts of seeds. On the approach of danger, it flies into the branches of trees, where it also nests, and where it cannot easily be distinguished on account of its yellowish-green, leaf-coloured plumage.

The **Common Sparrow** (*Passer domesticus*) and its relative the **Tree-Sparrow** have followed in the train of man all over the earth wheresoever the culture of grain is pursued (hence they are absent in remote and isolated forest villages). Their original home was probably in Asia, whence most of our cereals are derived. Indeed, their inconspicuous earth-coloured plumage points them out as original denizens of the steppes. (Compare with lark, quail, and partridge.) The common is easily distinguished from the tree sparrow by the colour of the plumage. (Common sparrow: top of the head ashy grey, no black spot in the region of the ear, wings with a yellowish-white transverse bar. Tree-sparrow: top of the head bright rufous, a black spot in the region of the ear, the wings with a pure white transverse bar.) The common sparrow has become intimately attached to man's society. It builds its very untidy nest preferably under gables, etc.; but on the ripening of the corn it leaves human habitations in order to take its fill in the fields. The tree-sparrow, on the other hand, builds its nest by preference in hollow trees, and only enters towns and villages in the winter, when driven by hunger. It then, like the common sparrow, makes its meals of all sorts of kitchen refuse. Both species feed their young upon insects, of which the old birds also consume large quantities. They, however, inflict considerable damage by biting off buds, and plundering fields, cherry-trees, and orchards. In this country the uses of this bird

Digitized by Google

and the damage it inflicts are about equally balanced. In a large part of North America, however, where they were introduced only a few decades ago, they have become, on account of their remarkable fecundity, a veritable pest to the farmer, against which no effectual remedy has yet been discovered.

The familiar **Canary** (*Serinus canarius*) is derived, as its name indicates, from the Canary Islands. It is still found there in a wild state, its plumage being of a greenish-yellow colour ornamented with blackish stripes (protective colouring). The uniform golden yellow or yellow and black plumage is the result of breeding, extending over about 300 years, on the part of man. (Compare with dog.)

The **Bullfinch** (*Pyrrhula rubricilla*) is another favourite cage-bird, which even learns to whistle tunes. The top of the head is covered by a circular black patch resembling a priest's skull-cap, hence the German name *dompfaff*, *i.e.*, "the canon." The back and wings are also of a glossy black, the latter crossed by two white bars. The under side in the male is of a beautiful scarlet-red, but in the female the colour is of an inconspicuous blue-grey. This bird only leaves the woods during severe winters in search of a few berries or seeds in the orchards; thus, unlike its relative the sparrow, its senses have not been sharpened through intercourse and struggle with man, to whose persecutions it falls an easy victim.

Of the numerous species of **Bunting** (*Emberiza*), we shall only mention the **Yellow-hammer** (*E. citrinella*), which in winter comes into our towns and villages in company with the sparrows, and is a frequent guest in our farmyards. The head, neck, and under side are of a beautiful yellow colour; the upper surface is reddish-grey.

The **Common Crossbill** (*Loxia curvirostra*) is an inhabitant of fir and pine woods, and makes its home wherever pine or fir seeds are good and plentiful. In such places we may see it hanging on to the fir-cones with its strong feet, which are equipped with long, powerful, and pointed claws, or on a branch holding with its feet a cone which it has bitten off, and from which it is picking out the seeds. For this kind of work it is well fitted by means of its crossed bill. (What is the legend in regard to the latter?) By pushing the point of the beak under one of the scales of the cone and turning its head aside to some extent, the bird lifts up the scale and lays bare the seed, which is then pushed into the mouth with the tongue, which is shaped like a shovel, and very protrusible. In consequence of the peculiar shape of the bill the bird cannot pick up seeds from the ground. Its bill and feet render the bird an adept climber—in fact, it has been called "the parrot of our forests." It breeds, like all birds, when food is abundant. (Why?) This mostly happens during the

Digitized by Google

winter, when it frequently revels in a superabundance of its favourite diet. The nest is constructed with much skill, and placed under over-

COMMON CROSSBILLS. (The adult birds in the foreground about one-third natural size.

hanging branches as a protection against snow. As the young are hatched with a thick coat of down they do not suffer from the winter cold, and, moreover, "a full stomach is a warm cloak"; besides, the

Digitized by Google

oily fir-seeds supply much heat. The bill in the young birds is straight, and only assumes the crossed shape later in life. It is a favourite cage bird, partly on account of its accomplishments as a climber, partly on account of its richly-coloured plumage. (Males several years old are carmine-red or yellow; females and young are grey or yellow.)

Family 2: Larks (Alaudictæ).

The Skylark (*Alauda arvensis*).

(Length 7 inches.)

The lark is a bird *of the fields*. In early spring and after the harvest, when there is no cover to hide it from its numerous enemies (see hare), its earth-coloured plumage, which renders the bird indistinguishable at a few paces' distance, furnishes it with an excellent means of protection. It builds its neat-looking nest out of roots and all sorts of grass-blades and stalks in a shallow depression of the ground between potato-stems or the like, where it is not easily discoverable. The *eggs* are earth-coloured, with green and white spots, and scarcely distinguishable from their surroundings. In spite of these means of protection, its enemies nevertheless manage to discover both eggs and young, and but for its remarkable reproductive powers (it lays annually two or three clutches of from five to six eggs each), the jubilant song of the lark would soon for ever cease to resound upon our meadows. (Compare with hare.) As with all song-birds, the song of the male is designed for the gratification of the female. Poets have glorified the lark, pouring forth its joyous strain, as, in spiral lines, it ascends into the heights above. As larks breed until the beginning of autumn, their jubilant songs do not cease until scarcity of food urges their departure. The bird's *food* consists of anything which the fields can supply: the tender sprouts of the young crops, all sorts of small insects, grains of corn and other seeds. Being omnivorous in its diet, the bill of the lark is not as strong as in the true grain-eating birds, but stronger than in purely insectivorous species (nightingale). Having to seek its food upon the ground, the lark is the *best runner* among the song-birds (the claw of the hind toe being of unusual length—lark-spur). Since its food (the young crops) is ready as soon as the sun has removed the white winter sheet from the fields, the lark returns to us early, with the melting of the snow. In the autumn the birds assemble in large flocks, and, ascending to great heights, take their departure. But in the South the birdcatcher has his snares spread ready for their destruction. The tuneful songsters are now doomed to tickle the palate of the epicure, under the name of

Digitized by Google

"Leipsic larks" (this abominable persecution having formerly been specially carried on in the neighbourhood of Leipsic)—a base return indeed for the pleasure these birds have provided for us during the months of summer.

Allied Species.

Our two other native lark species are as inconspicuous in the colour of their plumage as the skylark. The **Woodlark** (*A. arborea*) frequents, as its name implies, wooded heaths and moors, where it warbles forth tuneful airs from early morn to late evening, and even during the night. The **Crested Lark** (*A. cristata*), recognisable by the tuft of feathers on the head, is not so skilled a songster as its two sister-species. It is a rare visitor to Britain. In winter the pangs of hunger often compel the bird to accompany the sparrows, to pick up stray crumbs before house-doors, or to search out a few undigested corn-grains in the horsedung on the high-road.

Family 3: Swallows (Hirundinidæ).

The Swallow (*Hirundo rustica*).

(Length 7 inches.)

A. The Swallow as the Friend of Man.

No bird receives a heartier welcome than the returning swallow, the true harbinger of spring. With pleasure do we listen to its cheerful twitter, and watch with admiration the bold turns executed by this small "navigator of the air." The farmer, too, is pleased to see the bird building its nest in his barn or cowshed, for its presence is believed to bring him luck. He rejoices, too, in its family happiness, when for the first time he sees the young birds peep forth from their nest. The killing of a swallow is considered brutal, and we hear with disgust of the enormous quantities of this, as of other song-birds, which are captured and killed during their migration in Spain and Italy.

B. The Swallow as a Builder.

Immediately on its arrival the swallow inspects its old nest to see if it is still habitable. If such is the case, it is cleaned out and repaired; if, however, it has fallen into decay, a new one is built. The mud on the bank of a neighbouring pond forms its building material. Lump by lump it carries it up in its *beak*, and, clasping the wall with its *slender feet*, lays on the material layer by layer, like a mason. Its *viscid saliva* serves as a cement. Straw, feathers, etc., are mixed with the mud,

Digitized by Google

and give increased firmness to the structure, which is left open above. (Chopped straw is mixed with the mud used in some districts for building walls and even entire houses.) When dry, the nest is lined with a soft and warm padding of straw and feathers. After about two weeks' careful incubation the young emerge from the egg, and are fed and tended by the old birds with the utmost solicitude. As the nest is established in buildings, the young are protected against wet and cold, and being, moreover, placed close under the roof, the young birds are safe from the attack of mice, weasels, or polecats. From birds of prey the swallow is protected by its enormously rapid flight; the hobby alone is able to overtake it.

C. The Swallow as a Pursuer of Insects.

The food of the swallow consists of all sorts of small insects, especially flies and gnats, which it pursues in their own domain, the air.

1. Small creatures like this, however, provide but scanty fare, consisting as they do chiefly of such indigestible material as body-armour and wings. Hence only *small animals* can support themselves on prey of this description (compare with mole).

2. To satisfy its needs, the swallow requires large quantities of these animals, particularly since they are sparsely scattered over a vast space, and the fatiguing motion of the wings entails a great expenditure of force (compare with bat). Being, however, an extremely *nimble and rapid flier*, and able to accomplish astonishing distances day by day, the swallow manages to get sufficient food to satisfy its wants. In dull, rainy weather it flies close to the surface of the ground, where insects are to be found under these conditions. Flies or gnats sitting on walls it tries to rouse by rushing past them, in order to seize them on the wing. In warm sunshine, however, it rises high up in the air, still in pursuit of insects (consequently it is regarded as a weather-prophet). Seemingly at play, the bird performs all kinds of gambols in the air, now shooting forward headlong with the speed of an arrow, by turns ascending and descending, executing the boldest sideward movements, suddenly veering round and again darting forward on its former course. Now it seems to be dashing forward headlong against a wall; now, again diving downwards, we expect to see it disappear beneath the water. On the wing it drinks, on the wing it takes its cooling bath. In fact, the bird presents a picture of incessant life and motion. How is it able to perform all these astonishing manœuvres?

(*a*) The *wings* are long, narrow and pointed (compare, on the other hand, the fowl). They are set in action by powerful thoracic muscles,

Digitized by Google

which, in turn, require the presence of a large sternum with prominent keel.

(*b*) The forked *tail* forms an excellent rudder. The slightest movement of one of the long lateral rectrices alters the direction of the flight.

(*c*) The *neck being short*, the head and body form a pointed wedge, which cleaves the air with ease (compare with seal, otter, fishes, etc.).

(*d*) The *plumage* is smooth and in close contact with the body (diminishing friction). The upper side is of a glossy blue-black; forehead and throat chestnut brown; under-side rufous-yellow; each of the five outermost tail-feathers has a white spot.

(*e*) On account of the *legs* being short and weak, the weight of the body is considerably reduced. In consequence of its weak feet, the bird is not adapted for walking or hopping, but is capable of perching, and by reason of its sharp claws well fitted for clinging (in nest-building). The swallow, in fact, is as exclusively adapted to an aerial as, say, the ostrich to a terrestrial mode of life.

3. Being endowed with *acute sight*, the swallow can spy out the small insects which form its food even from a distance. One sudden turn, and the prey has vanished, as though it had been caught in a butterfly-net, in—

4. The *wide mouth*, the gape of which extends back towards the eyes. The *beak* alone is too small to be of any use for the capture of insects.

5. The bird can dispense with a long neck (see bat), since it seizes its food on the wing, and can turn with playful ease in every direction.

6. The nature of its food necessitates the *departure of the bird in autumn to the South*. At the end of September or the beginning of October, when the second brood is fledged and fit for travel, the birds assemble on the church steeples, roofs, etc., and perform a number of preliminary trials in flying. At last, on some fine evening soon after sunset, the feathered host rises for the last time, and commences its journey to the warm and insect-abounding shores of Africa.

Allied Species.

The House-Martin (*Chelidon urbica*), like the swallow, cultivates the companionship of man. It builds its nest mostly on the outside of houses, under projecting roofs and window-sills, in recesses, etc. (as a protection from rain. The nest is hemispherical, the opening being just large enough to allow the bird to slip through (protection against plunderers). If the opening happens to be too large, some vagabond sparrow is only too likely to take unlawful possession of the dwelling. The plumage of this confiding bird is glossy black above and white on

Digitized by Google

the under-surface.—The presence of a number of narrow canals or borings in the sandy or clayey bank of a stream is always a sure indication of the presence of a colony of **Sand-Martins** (*Cotyle riparia*). The birds construct these canals by means of their beaks, which, though short, are very sharp and hard. The tubes are often over 6 feet long, and widen out at their ends into a terminal breeding-chamber, or nest proper. The bird is easily recognised by the brownish-grey colours of the upper side and the white colour of the under surface, which is marked by a grey transverse band.

Family 4: Warblers (Sylviidæ).

The Nightingale (*Luscinia philomela*).

(Length 6½ inches.)

The nightingale returns to its nest of the previous year at the second half of April at a time when trees and bushes have not yet acquired their full dress of green. It is then that the inconspicuous *plumage* of this bird, resembling the colour of bark (upper side rufous, under surface light grey), provides an excellent protection against its numerous enemies. Even later, when earth has fully resumed its green garment, the nightingale for the same reason is only with difficulty to be distinguished among its surroundings. We can hear its song, but the bird is generally discovered only after a prolonged search. On the ground, especially when this is covered with dry leaves, the brown dress renders the bird quite invisible. (The nightingale has been termed a confiding bird, because it allows one to approach near to it. Does it not rather deserve to be called a bold bird? Compare, on the other hand, the golden oriole.) As it collects its *food* mostly from the ground (worms, insect larvæ, smooth-skinned caterpillars), it *frequents* dense bushes in gardens and parks, or the underwoods in the clearings of leafy forests. It also likes the neighbourhood of ponds and streams, where there is always an abundance of insect food, and where it can drink and bathe. The *beak* is awl-shaped, and of just sufficient strength and hardness for picking up the soft food. (Compare, on the other hand, the beak of finches.) The *bristle-like feathers* at the base of the beak act as tactile organs in rummaging among dry leaves. (Compare with the moustache hairs of mammals.) The long, strong legs enable the bird to hop along the ground or hold on to branches for prolonged periods. (Compare, on the other hand, the swallow.) The roughly-constructed *nest* is placed on the ground, or in the branches of the underwood, and invariably upon a foundation of dry foliage, so that it bears the closest possible resemblance

Digitized by Google

to a heap of leaves (protection). The *eggs* also are protected by their colour (olive green). As the birds breed only once during the year, the male only sings for a short time, until about the middle of June. (Compare, on the other hand, the lark.) The *song* of the nightingale is the most glorious that proceeds from the throat of any bird—now sounding softly, like the long-drawn note of a flute; now ringing out in joyous peals; sometimes plaintive and dreamy; at one time loud, at another soft. How varied is its beautiful, attractive song! and how soft and rich its splendid notes! Nor does the bird ever seem to tire of pouring forth its melodies, for only a few brief hours of the night are allowed for rest. (The word nightingale means "One that sings in the night.") And yet to think that men can commit the barbarous crime of slaying and consuming by thousands this unequalled songster, as is done in the countries of the Mediterranean during its migrations to Africa (August to September).

Allied Species.

In the districts of the Oder and Vistula the place of the nightingale is occupied by the **Northern Nightingale** (*L. major*). Its plumage is as inconspicuous and its song as beautiful as that of its Western relative. Perhaps the most welcome of our winter visitors is the charming little **Redbreast** (*Erythacus rubecula*); it takes its name from the red spot which adorns its throat. The upper side of this bird is of an inconspicuous olive-brown colour. Its food consists of all kinds of insects, which it picks up from the ground, and also of berries. The **Black Redstart** (*Ruticilla tithys*), the name of which, like that of the redbreast, is based on a fact (explain why), nests, careless of the doings of men, in holes in walls and on the beams of buildings. Its relative the **Redstart** (*R. phœnicura*) is a handsome bird (upper side blue-grey, throat black, breast and tail rufous, wings brown). It breeds in the holes of trees. Both species of redstarts feed on all kinds of insects, which they pick up from the ground. The birds of this family hitherto mentioned pass their life chiefly on the ground (ground-warblers), and therefore maintain, like the wagtails (which see) an erect attitude of body. Another group of warblers, comprising the genus *Sylvia* proper, assume a more horizontal position, which renders them capable of slipping through thick hedges. These birds only rarely descend to the ground. They live more especially on insects, which they capture on the wing or pick off from bushes. They do not, however, despise juicy berries. Of the numerous species belonging to this group, we shall only mention the **Garden Warbler** (*S. hortensis*) and the **Blackcap** (*S. atricapilla*). Both species are found everywhere in our gardens and

Digitized by Google

plantations wherever there are bushes in abundance. Their plumage is inconspicuous (upper side greyish-brown, under side lighter). The blackcap is easily recognised by the black patch on the head. Both are excellent songsters.

To the warblers we shall append two other *less closely related* species. The **White Wagtail** (*Motacilla alba*), in its black and white dress, is a very handsome bird. As it lives principally on aquatic insects, it frequents the neighbourhood of streams, brooks and ponds. It is, however, also fond of following the farmer's plough in order to pick up all sorts of insects and larvæ out of the furrows. Its long, stilt-like legs enable it to run quickly and for a considerable length of time, and also to wade in the water up to a certain depth. At each step it flicks up its long tail (hence the name wagtail). An equally pretty bird is the **Yellow Wagtail** (*M. campestris*), which is olive-green above and yellow below. It is fond of feeding around cattle, to whom it is of service by destroying the flies which worry them.

The Wren (*Troglodytes parvulus*).—(The German name of this bird is *Zaunkönig*, signifying "hedge-king." What is the legendary explanation of this name?) This tiny bird is an inhabitant of our thickest hedges, and slips with great speed and nimbleness through the most entangled bushes, its plumage, which resembles the colour of bark (brown with black stripes and spots), rendering it almost unrecognisable both in the hedges and on the ground. Its spherical nest, which has a very small entrance-hole leading to the interior, is always so well adapted to its surroundings as to be not easily discoverable, resembling in one place a heap of dry leaves, in another a lump of moss, while in still another place its outer walls are entirely built of lichens. The food of the wren consists of spiders and small insects (the beak is awl-shaped). It stays with us throughout the winter, being able, on account of its tiny size, to rummage about in nooks and crannies where many insects are passing their winter sleep. Moreover, the tiny fellow needs but little food. (Why?) Further, its *short wings* would hardly enable it to undertake a journey to warmer countries.

Family 5: Thrushes (Turdidæ).

The Blackbird (*Turdus merula*).

(Length 10½ inches.)

The plumage of the male is coal black and its beak golden yellow. In the female and young the upper side is blackish-brown, the breast rufous, and the bill brown. The *food* of the blackbird in autumn and winter (it is a resident) consists chiefly of berries. During the warm

Digitized by Google

season, on the other hand, it feeds exclusively on insects and their larvæ, earthworms, and snails. It accordingly frequents by preference moist localities, where the ground is covered with the decaying foliage of the previous year, and where there is never any dearth of its favourite food. For the same reason, it prefers places where there is a thick growth of bushes, which, moreover, afford protection from enemies, etc. As its food consists exclusively of soft substances, the *bill* is weak and awl-shaped. The bird uses it energetically in turning up the leafy covering of the soil. At the base of the beak, as in the nightingale, are found *bristle-like feathers* which function as tactile organs. The legs are long and powerful, enabling the bird to hop for hours long from branch to branch. The *nest* is large and built in a hedge out of dry sticks, moss, and damp earth. The blackbird produces several clutches of eggs annually, otherwise it would be speedily exterminated by shrikes, squirrels, and other predatory animals. The flute-like notes of the male may, therefore, be heard from the earliest spring till well into autumn. (Compare with lark.)

Allied Species.

The finest songster among the thrushes is the **Song Thrush** (*Turdus musicus*). The plumage of this bird is olive-coloured above, lighter coloured, with brown, heart-shaped spots, on the under side. It chiefly lives in woods. A very similar bird is the **Mistle Thrush** (*T. viscevorus*), which in autumn feeds chiefly on mistletoe berries. The undigested seeds of the berries are deposited with the droppings on the branches of other trees, so that the bird involuntarily spreads the parasitic plant. The **Fieldfare** (*T. pilaris*) is also a bird of inconspicuous plumage, which breeds more especially in Northern countries. It arrives in Britain in autumn in large flocks, and is caught in snares (springes). The flesh has a somewhat bitter taste owing to the fact that the bird feeds largely on juniper berries. Thousands of song-birds annually share a similar fate. Everyone who loves Nature and recognises the immense services which these birds render in the destruction of insects must condemn these wholesale massacres as a disgrace and an abomination.

Family 6: Shrikes (Laniidæ).

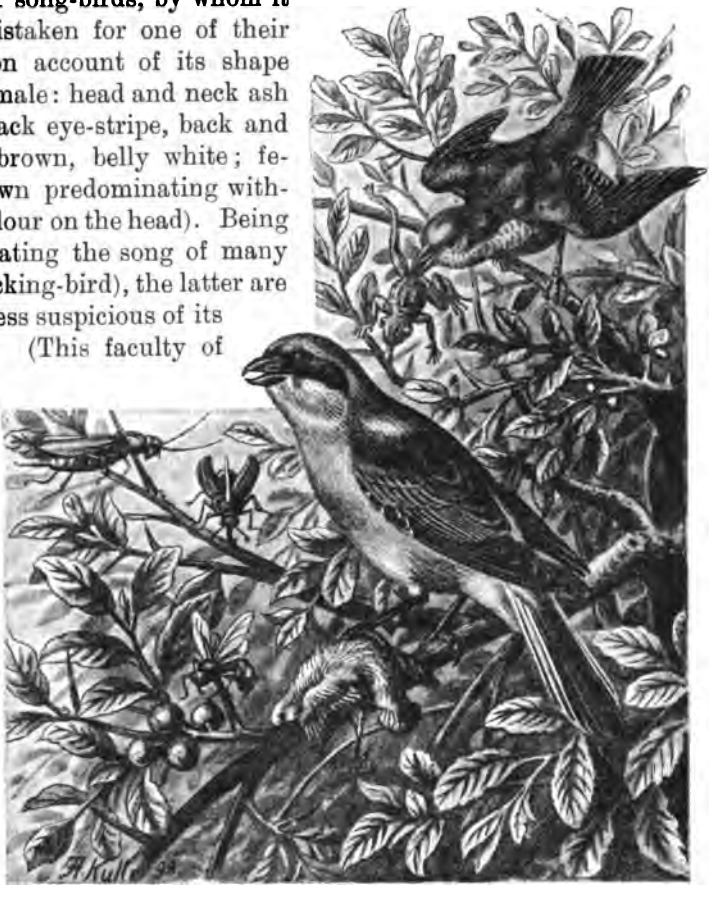
The Red-Backed Shrike (*Lanius collurio*).

(Length 7 inches.)

This bird is a wolf in sheep's clothing; by its shape and voice, it must be classed among the song-birds, but *in its mode of life it is a bird of prey*

Digitized by Google

(hence its common name, "butcher-bird"). From the summit of a tree or bush the bird surveys its surroundings (*sharp eyes*), watching for a large insect, a mouse, a frog, or small song-bird, and listening (*sharp ears*) for anything astir that rouses its suspicion. It also mingles in the society of other song-birds, by whom it is probably mistaken for one of their own number on account of its shape and plumage (male: head and neck ash grey, with a black eye-stripe, back and wings rufous brown, belly white; female: the brown predominating without ash-grey colour on the head). Being capable of imitating the song of many song-birds (mocking-bird), the latter are rendered still less suspicious of its real character. (This faculty of imitating the song of other birds is, however, shared by other quite harmless species; see starling.) Its *great bodily strength* enables it easily to overcome its victim. These it kills with its *beak*, which resembles that of a bird of prey (strong, the upper half of the beak bent over at the tip in the shape of a hook, with a toothlike process on each side). With a few blows of its beak it easily crushes in the skull of a song-bird, mouse, etc. In capturing its prey it makes use of its long *feet*, which are equipped with sharply-curved claws; they are, however, not sufficient for holding fast the prey whilst it is being torn to pieces. For this purpose the shrike impales its victim upon a thorn, and then pulls it to pieces bit by bit. Hence the bird only frequents places where thorny bushes are plentiful. After the



SHRIKES. (The bird in the foreground about four-ninths natural size.)

Digitized by Google

manner of a true beast of prey (see cat), the shrike goes on killing even after it has satiated its appetite. According to popular belief, it always kills nine animals before it begins its feast, and for this reason has been called "nine-killer." To the pleasant songsters of our woods and gardens the shrike is a terrible scourge, and therefore deserves to be exterminated. It is very sensitive to meteorological influences. Hence it does not arrive until the beginning of May, and leaves again at the beginning of August (for Africa).

Allied Species.

The Great Grey Shrike (*L. excubitor*).—This bird is not one whit less murderous in its habits than its red-backed relative, and being of larger size (over 10 inches) and greater strength, it will even attack partridges, quails, and thrushes. On its upper side it is bluish-grey, and white on the under surface. There is a black eye-stripe; the wings and tail are black, with white spots. It visits England only in the winter, but is resident in Holland and Germany all the year.

Family 7: Titmice (Paridæ).

The Great Titmouse (*Parus major*).

(Length about 6 inches.)

If during a severe winter we hang a piece of meat out of the window, we may be sure of a great tit soon making its appearance. It is a very handsome bird: the upper side yellowish-green; the under surface light yellow; the top of the head, throat, and a stripe on the breast, black. In the summer the titmouse fares better than in the winter season, there being then no dearth of *food*, which consists chiefly of insects and their eggs. The mere fact that it destroys by thousands (much movement, therefore much food) the eggs of our most destructive butterflies and moths—the Lackey (*Gastropacha neustria*) and others—proves it to be *one of our most useful birds*. It is also specially fond of the seeds of the poppy, sunflower, etc. The *legs* are short and strong, and provided with strongly-curved pointed claws, the birds being thus excellently adapted for climbing up branches and clinging to the swaying crowns of trees. They may even be frequently seen hanging upside down from the tips of dry branches. By means of its short, conical *beak* it manages to pull its food out of clefts and crevices, and to pick up the smallest insects and insect eggs. If it fails in obtaining food in this manner, it hammers loose a piece of bark after the manner of the wood-

Digitized by Google

peckers, its beak being very hard and firm. In the same manner it breaks open larger-sized insects (beetles), poppy-heads, and hard-shelled seeds. It remains with us through the winter (*resident species*), being able to search out insects (as well as their eggs) in their retreats. (Compare, on the other hand, the swallows.) The young assemble in autumn in great flocks, which rove about the country in vagabond fashion (*birds of passage*). Many succumb to the severity of the winter. This loss, however, is balanced by the great fecundity of this bird, which during the summer lays two clutches of about ten eggs each. The *nest* is a roughish structure, and is placed in all sorts of holes. The ground-colour of the eggs is white, and they are dotted over with red spots (see owl).

The **Blue Tit** (*P. cæruleus*) is a regular companion of the great tit at winter feeding-places. It is a pretty little bird, with blue, yellow and green coloured plumage, and during the cold season also takes to roving about in large companies.

Family 8: Starlings (Sturnidæ).

The Starling (*Sturnus vulgaris*).

(Length 8 inches).

The starling is a resident all the year round in England, but on the Continent migrates southwards, occurring only as a winter visitor in South Europe and North Africa. In the bright sunshine its black summer or *breeding dress* gleams with a green and purple sheen. After the moult the plumage appears to be spotted with white, owing to the black feathers now terminating in white tips. Its *song* sounds more like a "chatter" than a tune. It is an adept in the art of imitating the voices of other birds and different kinds of noises, such as the clatter of a mill, the creaking of a weather-cock, etc.; while in captivity it even learns to utter words and short sentences. (What stories or anecdotes do you know in connection with this?) Grapes and cherries are its *favourite food.* Gardeners and vine-growers, for this reason, justly persecute the bird. It almost makes good this damage, however, by its active destruction of insects and slugs. It is also fond of picking out ticks (which see) from the backs of sheep. Its long, sturdy *legs*, with their blunt nails, enable it to run about on the ground rapidly for hours. (Compare with swallow and titmouse.) With its long beak, which it opens as wide as possible, it investigates every crevice and every tuft of grass. In thus widely opening its beak, the *tongue*, which is possessed of a fine tactile sense, is allowed room to feel about for any

Digitized by Google

insects lurking within these recesses. Food of larger size (cherries, grasshoppers) is easily cut up by the sharp edges of the beak. The *nest*, like that of all *birds breeding in holes*, is an untidy structure. (Compare with it that of the chaffinch, etc.) Its eggs, however, are of light blue colour, a token that its ancestors built open nests, as in the absence of a convenient cavity it occasionally does itself. As holes in trees are often wanting, people frequently provide artificial nest-places for these birds (starling-boxes). The young birds, when fledged, unite with many others of their species in large flocks, which rove about over fields and meadows. In autumn the starlings of a district assemble every evening, and take up their quarters for the night in the reeds of a pond or lake. At the end of October, in Germany, they take their departure.

Family 9: Crows (Corvidæ).

The Rook (*Corvus frugilegus*).

(Length 17 inches.)

This familiar bird, with its *glossy blue-black plumage*, selects for its habitat fertile plains interspersed with small woods, the latter providing suitable conditions for nesting. The nests are constructed of dry sticks, and several of them are found in every tree of the rookery. At the breeding season the air is filled with the deafening noise of these birds. (Describe the sound of their voice.) The habit of the rook of living in societies efficiently protects it against the attacks of falcons, hawks, etc. The bird seeks its *food* principally in the field. It is omnivorous in its diet, picking up scattered grains and digging up the young sprouting seeds from the soil; it also plunders the pea-fields, but at the same time destroys enormous quantities of insect larvæ, slugs, and mice, and occasionally also a leveret or partridge. It is also very fond of carrion (hence explain the name "gallows-bird," applied to this species and its nearest relatives). As in most animals, however, the utility of this bird

HEAD OF ROOK.

Digitized by Google

and the damage it inflicts are about equally balanced. This, at least, is the view held by some naturalists; whilst according to others the rook makes good a thousandfold every damage it commits. By means of its large, sharp-edged *beak* (apart from its great strength), it is enabled to kill and tear up animals of largish size. It also uses the beak in boring for insect larvæ, burrowing for mice, and digging up the seeds of corn, etc. From continually working about in the earth, *the feathers at the base of the beak are worn off* in old birds, this portion of the bill being therefore surrounded by a naked ring of integument. The feet are powerful, and provided with blunt claws, and equally adapted for walking or hopping, as well as for holding on to branches. The bird is a winter visitor in Southern Europe and North Africa, but resident in England.

Allied Species.

The **Common Raven** (*C. corax*) is the largest member of the crow family. It is found throughout the whole of Europe, Northern Asia, and North America. It has entirely disappeared from many localities in consequence of continuous persecution. No animal, from the hare to the mouse, from the capercailzie to the smallest song-bird, is safe from the attack of this bird, which uses its large claws exactly after the manner of a bird of prey.

The **Carrion Crow** (*C. corone*) in all respects resembles the rook, with the exception that the feathers at the base of the beak are not worn off, inasmuch as the bird does not use its beak for digging into the earth. Like the raven, it remains with us during the winter, at which season it often visits villages and towns in company with the **Hooded Crow** (*C. cornix*). In this latter species the plumage is ash grey; the head, throat, tail and wings black. In the winter the bird departs from the more Northern countries to districts further South, so that in Central Germany it is frequently seen in places where it never breeds. It occasionally breeds in Britain and in Ireland, but is only abundant in winter, arriving in large numbers on the East Coast in autumn.

The Jackdaw (*C. monedula*).—This bird is a familiar inhabitant of towers, but also nests in cliffs and on trees. In the nature of its food it resembles the rook, though it does not dig in the soil. The colour of the general plumage is black, but the head, neck, and under side are ash grey. In the autumn it accompanies the rooks to the South. Large numbers arrive in autumn to pass the winter in England, while our own jackdaws are resident throughout the winter. The jackdaw is especially common in Cornwall, nesting both on the cliffs and in the chimneys and church-towers of the villages.

Digitized by Google

The **Magpie** (*Pica caudata*) is a handsome bird (glossy black, shoulders and belly white), but much given to plundering the young and the eggs of our pretty songsters. It builds its nest in high trees, out of dry sticks and thorns. As a protection against birds of prey it covers it with a roof, only a small entrance-hole being left, which leads to the interior. Like all the birds of this family, it is fond of conveying all sorts of glittering objects to its nest. (See "The Jackdaw of Rheims.")

The **Common Jay** (*Garrulus glandarius*) is even a greater destroyer of nests than the magpie; it is more murderous than the butcher-bird, according to the opinion of one of the most industrious students of birds in Germany. The plumage of this bird is yellowish-red; the wings are adorned with a beautiful black, blue and white coloured "speculum." The head bears a tuft of feathers. With its short, strong beak it can even crack open nuts. It also eats acorns, which it first softens in its crop, vomits up again, and then splits open. It lives in woods, and is very clever in imitating the notes of other birds.

The **Golden Oriole** (*Oriolus galbula*) is more distantly related to the birds of this family. It arrives in Germany from its African winter home about Whitsuntide (hence here also called "Whitsun bird"). It is a rare visitor to most parts of England, but more frequent in Cornwall and the Scilly Islands. The female is of a canary-green colour (protective colouring; see chaffinch), but the male, in its golden-coloured plumage, black tail and wings, forms one of our most handsome birds. This splendidly-coloured plumage renders the bird conspicuous, and hence it is very shy, and likes to hide itself in the dense foliage of the trees (see, on the other hand, the nightingale). The nest is built in the fork of a tree, and forms a beautiful hanging cradle, most artistically woven and plaited together by the united labours of the male and female birds. The beak is awl-shaped, which (as in the nightingale) points to an exclusively soft kind of food. This, in fact, consists of caterpillars. To so handsome a bird we need not grudge the few cherries or berries of which it occasionally pilfers our gardens.

The **Birds of Paradise** (*Paradiseidæ*) may be regarded as still more distant relatives of the *Corvidæ*. Their home is in New Guinea, North Australia, and the neighbouring islands. Amongst them we number the most beautiful of all birds (hence their name). The males especially are resplendent in the most gorgeous colours of metallic brilliancy, and are generally further adorned with plumes of marvellous shapes and forms. Nor does this conspicuous dress expose the birds to danger, as one might naturally suppose, for the countries they inhabit are free from the most formidable enemies of forest birds (monkeys, cats, martens,

Digitized by Google

and squirrels); nor are they much exposed to the attack of birds of prey in the impenetrable forests and dense leafy tree-tops in which they hide themselves.

ORDER VII.: PIGEONS (COLUMBINÆ).

BEAK at the tip with a convex horny covering; at its base covered with soft fleshy skin. Nostrils slit-like, covered with cartilaginous scales. Edges of beak not overlapping (see fowls). All the toes articulated in the same plane. Young helpless.

The Domestic Pigeon (*Columba livia*).

A. Origin and Varieties.

It is now generally agreed among naturalists that all the races of our domestic pigeons are the descendants of the rock-pigeon (*C. livia*). This bird inhabits in large flocks the steep cliffs and inaccessible rocks of the coasts of the Atlantic and Mediterranean, but occurs also in similar situations in Abyssinia, India, and Japan. It nests in caves, and in the colour of its plumage (blue-green, throat glossy metallic green, wings with two black bands), in shape, and mode of life, so closely resembles our dovecot pigeon, or "blue rock," that it is frequently very difficult to distinguish them. The following remarks will, therefore, more specially apply to the last-mentioned form of this species.

The pigeon has been domesticated from times immemorial (mentioned in Bible. Why?). By means of constant selection (see dog) numerous races or varieties have been produced, which frequently exhibit in shape, colour, formation of beak, feet, etc., more considerable differences than distinct *species* of birds. Compare, for instance, on the one side such birds as the common and hedge sparrow and the redbreast and redstart, and on the other side the common pigeon, the pouter, the nun, the fantail, or other breeds.

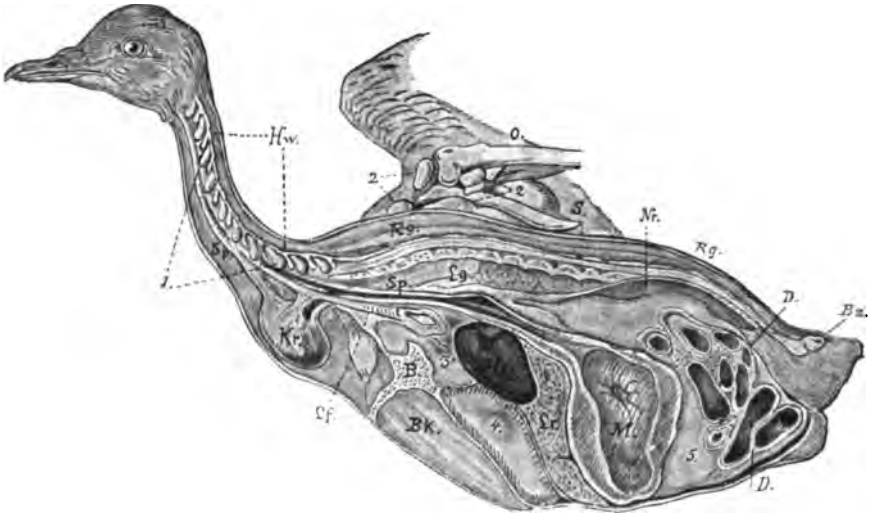
B. The Pigeon a Grain-eating (Granivorous) Bird.

At sowing time pigeons follow the farmer in search of scattered seeds, and they again make their appearance for a share of the produce at harvest-time. While the blades of corn, etc., are still standing the birds are unable to despoil them of their seeds. (Why not?) When, however, the corn has been cut and spread, and the peas, lentils, and vetches ripen, the pigeons often gather in considerable plunder from the fields. They, however, make good the damage by actively destroying the

Digitized by Google

seeds of all kinds of noxious weeds. Thus, as many as 3,500 seeds of the common vetch have been found in the crop of a single pigeon. In winter the tame birds have to rely on man for their food, the wild rock-pigeons, which nest in the North, departing to the South at this season.

1. During a great part of the day the pigeon roves over the fields in search of food. Its elongated *shape, short neck,* powerful *muscles of the breast* (high sternal keel), and the long pointed *wings* adapt it for rapid flight. (Compare with swallow and domestic fowl.) We are all familiar with the rapid flight of carrier-pigeons (how are these birds employed



LONGITUDINAL SECTION THROUGH BODY OF PIGEON.

Hw., Cervical vertebræ; Rg., spinal column; O., humerus; Sch., scapula; B, sternum, with crest, Bk.; Sp., œsophagus; Kr., crop; M., muscular gizzard; D., intestine in several sections; H., heart; Lr., liver; Nr., kidneys; Bz., uropygial gland; Lf., trachea; Lg., lungs; 1—5, air-sacs.

and trained?), which can easily accomplish in an hour a distance of about forty-four miles.

2. The pigeon has *keen sight* (large eyes), being able to discover a grain of corn, pea, etc., at a considerable distance.

3. While in search of food the bird walks along the ground for a considerable time, constantly nodding its head. The *legs,* though not so strong as in the gallinaceous birds (which see), are nevertheless equal to this task, especially as the pigeon does not, like the fowl, rake up its food from the ground. The posterior toe (hallux) touches the ground in walking. (See, on the other hand, domestic fowl.)

Digitized by Google

4. The *beak*, which is weak and cornified only at the tip, is adapted only for picking up small grain, and not for dividing these into smaller portions—a task which is performed by

5. The organs of digestion (see above illustration), viz.:

(*a*) The *crop*, consisting of two lateral dilatations of the œsophagus, and

(*b*) The *glandular stomach*, or *proventriculus*, a dilatation of the lower portion of the œsophagus, in which the food is softened by the water which is taken in (see Section 6), and by the slimy secretions of mucus glands.

(*c*) The grinding of the grain swallowed for food takes place in the *gizzard*, the walls of which consist of very thick muscles. It always contains small stones or pebbles (quartz grains), which are swallowed with the food. By the contraction and subsequent dilatation of the muscular walls of the gizzard (see Part I., p. 5), the internal cavity of this organ is alternately enlarged and diminished, whereby the food is subjected to a grinding motion, and gradually crushed up into finer and finer particles, the pebbles being at the same time gradually worn down and continually replaced by other sharp-edged ones. (The grating noise produced by these foreign bodies in the gizzard may be heard from outside in some gallinaceous birds—*e.g.*, a turkey—by applying the ear to the bird's body.) To protect the gizzard from being injured by these stones, its inner surface is lined with a strong horny membrane (see Section 8, p. 147).

The cavity of the stomach being, however, small, only a small quantity of grain can be ground up at a time; and as the bird needs much more food than the stomach can hold for the time being, the surplus is stored up in the *crop*, which thus acts as a store-chamber. (Compare ruminants.)

6. The pigeon requires a good deal of water, for the purpose of softening the hard-shelled grains which constitute its food. In drinking the bird pushes its beak to a fair depth into the water, the slit-like *nostrils* being closed at the same time by the cartilaginous scales. In this way the beak is converted into a tube, as it were, by which the water is sucked in.

C. Enemies.

1. The pigeon is a *defenceless* bird (compare beak, feet, and claws), and consequently *shy* and *timid*.

2. From hawks, falcons, crows, it is protected by its *sharp sight* and *rapid flight*.

3. By building its *nest* in caves and other *inaccessible* spots, the rock-

Digitized by Google

pigeon insures itself against the attack of martens and other mammalian beasts of prey. The tame pigeon also selects for its nesting quarters places of similar character (such as towers, pigeon-houses supported on pillars, boxes fixed against a wall, etc.). Like its ancestral parent, it never, or only exceptionally, settles upon trees.

D. The Young Birds.

1. Like all cave-breeders, the pigeon builds a rough *nest* out of straw and a few feathers, for, being sufficiently protected by its hiding-place, the bird does not need a structure artistically contrived to resemble its surroundings. (Compare, on the other hand, nightingale and chaffinch.) For the same reason, also,

2. The *eggs* are without protective colouring (see chaffinch), but are pure white (see owl). The bird produces annually from three to six clutches of two eggs each, which are incubated by the male and female alternately.

3. The young are at their birth blind, and quite helpless (*aves altrices*). As they leave the egg completely naked, they have to be warmed by the parent birds. Neither are they able at this stage to digest the hard granular food. Accordingly, for about the first twenty days of their existence they are fed upon a fatty, crumbly substance formed at this period in the crop of the parents (so called pigeons' milk). Afterwards they are fed with grain which has been softened in the crop of the parents.

4. The young are reared with great difficulty during the first days of their life, much more so than is the case with other birds. This accounts for the pigeons only laying a *few eggs at a time*, for it would not be able to rear more than two young birds.

5. The support and nourishment of the young, even during a later period, entails much trouble and labour for the parent birds. Hence, like all birds the young of which are reared in the nest, pigeons are monogamous in their sexual relations. (Compare, on the other hand, the domestic fowl.) On account of the tender affection which the pair show for one another, the dove has been for ages the symbol of love.

Allied Species.

The **Ring-Dove** or **Wood-Pigeon** (*Palumbus torquatus*) is a familiar inhabitant of our woods. It prefers pine and fir woods, its food consisting chiefly of the seeds of coniferous trees. The nest is a simple structure, which it builds in the dense branches of bushes and young trees. The plumage is blue-grey, with a white spot on each side of the neck (hence name ring-dove).

Digitized by Google

Another species nesting in our woods is the **Turtle-Dove** (*Turtur auritus*). It is a summer visitor in England, breeding in the region south of Yorkshire, but rare to the northward. In the South of Europe, North Africa, and Western Asia it is a very common species. It obtains its name from its cooing, which sounds like "tur-tur" frequently repeated. On account of its gentleness and handsome plumage (rufous in general, with four black white-edged stripes on each side of the neck), this bird, as well as the **Collared Turtle-Dove** (*T. risorius*), is often kept in cages. The last-named species derives its name from the voice of the male, which resembles the sound of human laughter. Its home is on the desert steppes of East Africa and Western Asia. The plumage, accordingly, is cream-coloured (Isabelline), like the soil on which it lives. (Compare with lion and gazelle.) The nape of the neck is adorned with a black transverse band.

The **Passenger Pigeon** of North America (*Ectopistes migratorius*) has acquired general notoriety on account of the enormous flocks in which it roves about the country in search of food. Flocks of this bird have been observed consisting of many millions of individuals, aggregated in such density as to obscure the sun, and by their acid droppings ruining woods to the extent of many square miles. Fields visited by such hosts are destroyed in a very brief space of time. These birds breed in woods in the neighbourhood of which they can obtain food in abundance, as many as 100 nests being sometimes found in a single tree. Owing to the destruction of the forests, however, these birds are being rapidly exterminated.

ORDER VIII.: GALLINACEOUS BIRDS (GALLINACEI).

Beak short, somewhat curved anteriorly, hard at the base. The edges of the upper portion of the bill overlapping those of the lower half; nostrils having the form of clefts, and covered by a hard, scale-like flap. Wings generally short and arched. Legs robust. The posterior toe (hallux), when present, usually articulated at a higher level than the anterior toes. Young *independent* of nest from birth ("precocious").

Family I Pheasant-like Birds (Phasianidæ).

The Domestic Fowl (*Gallus domesticus*).

A. Origin and Varieties.

History does not tell when the fowl was first domesticated. It is, however, certain that more than 1,000 years B.C. it was kept as a

Digitized by Google

domestic bird in India and China. Naturalists regard the **Jungle-Fowl** (*Gallus bankiva*), which inhabits the primeval forests of Eastern India and the Sunda Islands, as the ancestral parent of this useful bird.

The various breeds of fowls produced by man owe their origin to the different purposes or objects for which they were destined—*e.g.*, size and number of eggs (layers), delicate and tender flesh (fowls for the table), or shape and plumage (ornamental or fancy birds). In our poultry-yards, in addition to the common barndoor fowl, we also frequently meet with the Italian and Spanish breeds.

However the different breeds may vary in shape and colour of plumage (give description), they are all distinguished by the possession of a red, jagged, fleshy comb on the top of the head, two cutaneous flaps (wattles) on the lower beak, and naked cheeks. The males always surpass the females in brilliancy of plumage, in the size of the comb and wattles, and are distinguished by the possession of curved, sickle-shaped tail-coverts, which overhang the roof-shaped tail. As the plumage is not oiled (uropygial gland very small), the fowl is very sensitive to rain, from which it seeks shelter beneath a roof or other protection. It cleans itself with sand or dust, not water.

B. The Fowl a Ground Bird.

As the air is the realm of the swallow (which see), the ground is the domain of the fowl; and whereas the former hardly ever touches the ground, the latter passes its whole life there, and leaves it but rarely, and then unwillingly.

I. The *flight* of the fowl is heavy, awkward, and fatiguing. This is due to the following facts:

1. The *wings* are short, rounded off, and saucer-shaped (compare the swallow).

2. The *muscles of the breast* which move the wings are comparatively weak. The *sternum* is accordingly feeble and its crest low.

3. The *body is relatively heavy*, all the bones being strong, and only few filled with air, and then only to a slight extent.

II. Being a denizen of the ground, the legs of the fowl are strong and robust, and adapt it for running rapidly and with endurance. The muscles of the thigh ("the leg" of the bird as presented on the table) are very strong; the tarso-metatarsus is of moderate length and robust, like the toes, the posterior one of which is articulated at a higher level than the anterior ones. The claws are strong, blunt, and somewhat curved (compare claws of raptatorial birds), and obtain a powerful purchase against inequalities of the surface of the ground (compare with hoofs of the horse and ox). The poor flight-capacity of the birds is

Digitized by Google

counterbalanced by their power of rapid running. It is only when compelled (give instances) that the fowl takes to flight, and it only seeks the aid of its wings when the power of its legs proves insufficient. It is by running that it tries to evade its enemies (hawks, cats, dogs, etc.), and, in fact, it spends the whole day "on its legs" in search of—

III. Its *food*, which it finds on and under the ground.

1. With the *claws* of its powerful front toes it scoops about untiringly among dry leaves, in the loose soil, or on the dung-heap, looking for all sorts of small worms, larvæ, and tiny seeds.

2. By means of its *sharp eyes* it can detect fragments so minute as to be undiscoverable by human sight in the dark soil.

3. The fowl cannot, however, satisfy its wants by what food it picks up. It requires in addition to be fed. Among its favourite morsels are grains of corn, barley, etc., juicy cabbage or lettuce leaves, earth-worms, smooth green caterpillars, and cockchafers. It is, however, also satisfied with all sorts of table refuse. The smaller fragments are swallowed whole; larger ones (cockchafers, caterpillars, boiled potatoes) are chopped up with the powerful *bill*. With the aid of the latter, also, it cuts up leaves piecemeal, the sharp edges of the upper beak overlapping and cutting against those of the lower bill in the manner of shears.

4. As the food consists principally of grains, the fowl, like the pigeon (which see) is provided with a *crop*, a glandular *proventriculum*, and a powerful *muscular gizzard*.

5. The fowl does not *drink* in the same manner as the pigeon (which see), inasmuch as the flaps which cover the cleft-like *nostrils* are hard, and the latter therefore cannot be closed. It drinks really by scooping up water in the concavity of the lower beak, raising its head and allowing the water to run down into its throat.

C. The Young.

1. Artificial breeding has produced the result that a good hen lays 150 *eggs*, and even more, in the course of a year. (Why does no bird living in a free state of nature produce so large a number?) Only about fifteen to twenty, however, are given to the "clucking hen" to be incubated. After about three weeks the *young chicks* emerge from the egg, little things clothed in yellow down, following the mother from the day of their birth, and picking up their own food. One cannot picture a more pleasing sight than that of a hen followed by her young ones! Whenever the mother happens to find a grain or a little worm, she never fails to call up the chicks to receive the morsel. With the utmost self-sacrifice, she defends her dear ones against dangers of every kind, and

Digitized by Google

at night and in raw weather covers them snugly under her protecting wings.

2. The young birds leave the *nest* soon after emerging from the egg, at a time when they are still unfledged. Hence the nest must be placed on the ground, or, at least, in such a position that the chicks may be able to reach the ground. It, in fact, consists of a shallow pit or depression formed by the hen by turning her body round and round in the straw, or prepared for her by her owners.

3. The young birds at once go in search of their own food (compare, on the other hand, those which stay in the nest); hence the mother hen is enabled to hatch *a large number of eggs* at one and the same time, and this also explains why

4. The birds are *polygamous* in their sexual relations, a single cock having several wives, and not in the least concerning himself about the rearing of his progeny. The male birds engage in fierce *fights* for the possession of the females, attacking each other furiously, and dealing out mortal wounds with their beaks and the *spur* which is developed above the hind-toe; nor is the battle at an end until one or other of the combatants has quitted the field (cockfights in England, Spain, and other countries). The cock, moreover, uses these same weapons with fearless courage in defence of his family against such enemies as the goshawk and sparrow-hawk.

Allied Species.

In addition to the domestic fowl, there are to be found in our poultry-yards gallinaceous birds originating from other continents—*e.g.*, the **Guinea Fowl** (*Numida meleagris*), which was introduced from Africa.

The **Turkey** (*Meleagris gallopavo*), whose native home is in the immense forests of North America.

The **Peacock** (*Pavo cristatus*), originating from the dense mountain forests of the East Indies, has been kept as an ornamental bird for some thousands of years. (Describe these well-known birds, and give an account of their habits and mode of life.) None of these birds, however, have become naturalized in Europe.

It is otherwise with the **Pheasant** (*Phasianus colchicus*), which often leaves man's protection (pheasant preserves), and lives like natural game. Its native home is in Western Asia. As in most gallinaceous birds, the male, requiring less protection than the female, is distinguished from the latter by a more brilliant plumage, the cock-bird being resplendent in lustrous greenish-blue and rufous tints, whilst the plumage of the hen is of a dusky greyish-brown colour. Even more brilliant is the

Digitized by Google

plumage of the males of the **Gold and Silver Pheasants** (*Ph. pictus*, *Gallophasis nycthemerus*). In the plumage of the former a golden yellow and a magnificent red are the predominating tints, whilst in the latter species the silvery white colour of the back is in brilliant contrast with the deep black of the under surface. Both species have been introduced from China.

Family 2: Partridges and Quails (Perdicidæ).

The Partridge (*Perdix cinerea*).

(Length 12 inches.)

In the structure of its wings and feet the partridge exactly resembles the domestic fowl; hence, like the latter, it is a bad flier, but a rapid runner. In consequence of the hardness of the feathers, the flight is noisy, rustling. Its food, too, is the same as that of the fowl (*beak* and *claws* also as in the latter). The *plumage*, like that of other *denizens of the fields* (compare hare, lark), is of an inconspicuous earthy colour. The ashy grey back is dotted and lined with numerous brown spots, light streaks, and black zigzag lines, so that a bird sitting on the ground can scarcely be distinguished, even at a short distance. (The importance of this for the incubating hen!) The under surface in the male is of a lighter colour, and bears a brown, horseshoe-shaped spot. In the spring the "coveys" separate into single pairs (monogamy). The female lays ten or more *brownish-grey* (protective colouring) *eggs* in a flat, circular depression of the soil, which is padded with straw, grass, etc. The nestling plumage is a mixture of black, brown, and yellow, and renders the *young* not easily distinguishable. Nevertheless, in spite of this protective colouring and the watchful care of the parent birds, many a nestling falls a prey to its numerous enemies (see hare). The worst foe of the partridge, however, is the winter. It may manage to survive as long as it is still able to scrape away the snow and get at the young crops beneath. When, however, the surface layers of the snow freeze to icy hardness, whole coveys of the birds often die miserably of hunger. It is only owing to its *great fecundity* (see hare) that this *delicate game bird* has not as yet entirely disappeared from our fields.

The Quail (*Coturnix communis*).

The quail nests in the concealment of high-standing corn. Its familiar call-note has been considered by pious Germans to resemble the words "Fürchte Gott" (Fear God). The English rendering of the sound is "Wet your lips." The plumage of this bird also, in accordance with its habitat, is of an earthy colour (brown, with yellowish-white stripes).

Digitized by Google

Being a much smaller and weaker bird than the partridge, it would not be able to penetrate the snow to the young crop beneath, and accordingly it is migratory, like the lark. Its wings are less arched than those of the partridge, and the three first primaries are elongated, arrangements which adapt the bird for a more rapid flight. Many quails winter in the South of Europe, where they are caught in many thousands; others cross the sea.

Family 3: Grouse Family (Tetraonidæ).

The **Capercailzie** (*Tetrao urogallus*) was formerly met with abundantly in the pine forests of Northern and Central Europe. Its ranks, however, have now been considerably thinned by incessant persecution. It was originally a native of Britain, but became extinct, and has been reintroduced. The male (length about 40 inches) is a handsome bird of dark-coloured plumage (head and neck blackish-blue, breast glossy blackish-green, back and wings brown, tail black). The plumage of the female —which is about one-third less in size—on the other hand, displays a mixture of black, grey, and brown—in fact, a colour showing but slight contrast from that of the soil (protection in breeding and taking care of the young birds). In the spring the males compete for the favour of the females. Sitting on a branch, the cock erects its feathers, spreads its tail, allows its wings to droop, and utters the most curious sounds. At this time it is blind to all dangers, and, though at other times a very shy bird, allows the sportsman to steal close up to it. Its food consists of tree-buds, leaves, berries, seeds, and insects.

The **Black Grouse** (*T. tetrix*) frequents birch-woods by preference. The male (blackcock) is about the size of the domestic cock. The head, neck, and breast are of a shiny steel blue, the wings brown, crossed by a white band. The outer feathers of the black tail are curved outwards into the shape of a lyre (a favourite decoration for the hats of sportsmen in Germany). The female is smaller, and in colour of plumage resembles the female capercailzie (greyhen).

The **Hazel Grouse** (*Bonasa sylvestris*) does not occur in the British Islands; on the Continent it inhabits mountain forests, and is actively hunted on account of its excellent flesh. The males are but slightly distinguished from the females. The plumage is reddish-brown, spotted with black and white.

The **Common Ptarmigan** (*Lagopus mutus*) inhabits the Northern countries of the Old World and the heights of the Alps. Its earth-coloured summer plumage is exchanged with the advent of the cold season for a white winter garment. (Compare with Alpine hare and ermine.)

Digitized by Google

The **Willow Grouse** (*Lagopus lagopus*) is similar to the ptarmigan, but has a stouter beak and a longer wing, and a different colour in summer; in winter it turns white, like the ptarmigan. It is circumpolar in range, but is not found in Britain, the **Red Grouse** (*L. scoticus*) being the British form of it. The red grouse does not turn white in winter, and is the only species of game-bird peculiar to the British Islands.

ORDER IX.: CURSORIAL BIRDS (CURSORES).

BIRDS incapable of flight, without flight or tail feathers or sternal crest, but provided with powerful feet adapted for running. Young "precocious."

The African Ostrich (*Struthio camelus*).

(Height up to nearly 8 feet.)

A. Its Home.

The home of this bird is on the immense desert plains of Africa and Western Asia, though, in districts entirely devoid of vegetation, it can no more exist than any other animal. From the earliest times it has been incessantly pursued for the sake of the magnificent feathers of its wings and tail. As in consequence of this persecution the bird was steadily becoming rarer, it became at last necessary to domesticate it. In South Africa especially large ostrich-farms have been established in recent years. The full-grown birds have their feathers clipped off with shears about every eight months, those of the first quality realizing on the spot as much as £25 the pound avoirdupois.

B. A Denizen of the Desert.

Like the camel, the ostrich is a true denizen of the desert. (Compare it with camel.)

1. Its food consists of desert plants and their seeds, insects, and other small animals. With its food it takes in stones, which in the *gizzard* (see pigeon) assist in crushing up hard-shelled seeds. As, however, the places which it frequents are usually poor in food-stuffs, the bird, in order to obtain sufficient nourishment, is obliged daily to rove over a great deal of ground. In order to reach water for drinking purposes, which the bird likes to visit daily, it has usually to travel a considerable distance. And if the spring dries up, and its own domain ceases to supply it with a sufficient amount of food, the bird is compelled to

Digitized by Google

perform long journeys, often through the most barren deserts, in order to find a more hospitable region. Accordingly, the ostrich *must be capable of easy and rapid progress.*

2. *Of flight*, the mode of motion of birds *par excellence*, the ostrich is, however, *incapable*, for—

(*a*) The *great weight of the body* alone (up to nearly 170 pounds) would render flight extremely difficult; whilst

(*b*) The weakness of the wings and the absence of flight-feathers as well as of steering-feathers, or rectrices, renders flight impossible; for the large feathers of the wings and tail have soft, flexible shafts, whilst the barbs, having no hooks, are wholly disconnected, and instead of forming a continuous surface (see p. 148), give the vane a frayed appearance (plume). In the male these feathers are of a dazzling white colour, the body being covered with feathers of similar form, but of a deep black. The plumage of the female is a brownish-grey, the plumes of the wing and tail being dingy white.

AFRICAN OSTRICH.
(The bird in the foreground about one-fiftieth natural size.)

(*c*) In correspondence with the incapacity for flight, we find that the bones constituting the *shoulder-girdle* (see p. 141) are in part rudimentary, the sternum is small and weak and without keel, and the *pectoral muscles* which actuate the wings are feebly developed.

3. The incapacity for flight, however, is counterbalanced by *enormous running powers*, the ostrich being able to outstrip the fastest racehorse.

(*a*) The *legs* are very *tall* (tarso-metatarsus long; the paces from 7 to 10 feet in length). They are naked, with the exception of a few bristles at the lower portion of the thigh. A covering of feathers would impede the bird in running. (Compare breeds of fowls with feathered legs, so-called "stockinged" birds.) The thighs are extremely *muscular* (cursorial legs).

(*b*) The legs, moreover, *are articulated at the middle portion of the trunk*, so that the latter acquires a horizontal position, the bird being

Digitized by Google

ereby enabled to run with greater steadiness and surety. (Compare e waddling gait of the duck, in which bird the legs are articulated at ie posterior end of the body.)

(*c*) As in the case of fast-running species among mammals (horse, azelle, etc.), the *toes* are few in number, viz., two. They are provided ith *broad soles*, whereby the bird is prevented from sinking in the and. The inner one of the two toes is especially large, and provided ith a *hoof-like nail* (for firm application against inequalities of the ound). The upper surfaces of the toes and the anterior surface of the rso-metatarsus are covered with large *horny shields or plates*, all the her parts of the leg with a *stout integument*. By these provisions the gs are rendered insensible to the sharpness and heat of the desert sand. As in the camel, there is a *horny callosity* upon the middle of the breast. (What is its meaning?)

(*d*) While running fast, the long-legged bird uses its wings as *balancing rods*. It has also been noticed to employ them as aerial oars, and in a favourable wind as sails.

4. In correspondence with the height of the leg, we have the great *length* of the neck (for the purpose of reaching the ground; compare with giraffe and camel). Head and neck are scantily covered with bristle-like feathers.

5. In consequence of the length of its legs and neck, the bird, with its sharp, far-sighted *eyes*, is enabled to survey a vast extent of ground, and hastens off as soon as it catches sight of an enemy (a man, or one of the feline beasts of prey). For this reason also the timid zebra likes to associate itself with the ostrich, thus taking advantage of the height of the bird's head, which enables it to act as sentinel.

C. Family Life.

A single male and several females constitute an ostrich family (see domestic fowl). The females at the beginning of spring (why at this time?) lay one by one up to thirty eggs into a common *nest*, which is nothing more than a hole scratched in the ground. The weight of each *egg* is equal to that of about twenty-four hen's eggs. Recent observers state that the hen sits on the eggs in the day-time, the cock at night.

The *young* (who are "precocious") are protected with self-sacrificing affection by their parents, especially the male birds, who will attack even hyænas, foxes and jackals in their defence. With its feet the ostrich delivers blows which may prove dangerous even to man. (Compare with horse.)

Digitized by Google

Allied Species.

The **American Ostrich** (*Rhea americana*) inhabits the large grassy plains of South America, the pampas. In the colour of its plumage brown is the predominant tint, and its feet, like those of the two following species, are three-toed. In its mode of life it closely resembles the African ostrich, though it does not attain to the size of the latter species.

The same applies to the **Australian Ostrich**, or **Emu** (*Dromæus novæ-hollandiæ*), the plumage of which consists of greyish-brown bristle-like feathers. Its home is in the open bush-forests of Eastern Australia.

The **Cassowary** (*Casuarius galeatus*) is also an inhabitant of forests. Its black plumage bears a still closer resemblance to hairs than that of the emu. Its wings are completely atrophied. The organs, indeed, are of even less use to it in the dense primeval forests of its home, New Guinea and the Moluccas, than are those of the ostrich in its course over deserts and steppes. The head and neck are naked, and vividly coloured with green, blue and red. On the forehead the bird carries a horny helmet-like crest (hence name *galeatus*).

The **Kiwi** (*Apteryx oweni*) is a very remarkable animal, resembling the ostriches only in the shape of its feathers, the absence of the quill-feathers of the wings and tail, and several peculiarities in the structure of the skeleton (see above). It is about the size of a domestic cock, and inhabits the damp primeval forests of New Zealand. The colour of its bristle-like feathers is a dusky greyish-brown, in correspondence with its nocturnal mode of life. With its long, slender beak it probes the soft soil, after the manner of a snipe (which see), in search for food, which consists principally of worms and insect larvæ. In this occupation the soft sensitive tip of its bill serves as a tactile organ. On account of the position of the nostrils at the tip of the bill, it can also perceive its prey by the smell. From the base of the bill arise large tactile bristles. The eye is very small, indicating but feeble sight (compare mole). The feet are short, but strong, and furnished with three large toes in front and an additional short toe (hallux) behind. This peculiar bird is said to glide about during the night stealthily, like a rat. Owing to incessant persecution, it is gradually becoming scarcer.

ORDER X.: WADERS (GRALLATORES).

Legs tall in consequence of a long tarso-metatarsus. Toes free, or united by a short membrane (rarely webbed). Beak and neck generally long. Young either "precocious" or helpless.

Digitized by Google

Family 1: Storks (Ciconiidæ).

The Common Stork (*Ciconia alba*).

(Height 30 inches.)

A. The Stork a Protégé of Man.

In Holland and Germany, young and old rejoice to see the storks returning to their home with approaching spring, and reoccupying their old nest on the high roof of the church or the gable of the farmhouse; for, like the swallow, the stork is a welcome and inviolable guest. The farmer willingly presents the bird with a cart-wheel as a foundation for its nest, for the house which harbours a stork's nest is supposed to be safe from lightning and fire. Studiously he watches the pair repairing the nest which has been torn by winter storms, prancing about on the summit of the roof, and producing with their beaks their peculiar rattle. Presently he sees the male bringing food to the sitting female, then both parents tending and nurturing the young ones, and the latter, after they have left the nest, taking their first lessons in flight; and finally, with the approach of autumn, he watches "his storks" joining their mates from the whole neighbourhood in one huge swarm, previous to their departure to the winter home.

Where no nesting-place has been provided for it, the stork establishes its dwelling on a lofty tree. It has virtually no *enemies*, but in case of necessity is well able to defend itself, its young, and *eggs*, which are white (no protective colouring). Hence the conspicuous colour of its plumage does not expose it to danger. All parts of the plumage are white excepting the flight-feathers, which are black; beak and legs red.

In England the stork is an occasional summer visitor in the southern and eastern counties, and if unmolested would probably breed there regularly. In Scotland and Ireland it has very rarely been seen.

B. Food.

The stork is a thoroughly *predaceous* bird, feeding upon all the larger animals of marsh, pond or meadow which it is able to master. It consumes large quantities of amphibians, especially frogs, reptiles, snails, earth-worms, and all kinds of insects. Small fishes, young rabbits, large numbers of the eggs and young of ground-breeding birds (name some), also constitute its prey. On the other hand, it devours large numbers of mice, and is not even afraid of attacking the viper.

1. As its food thus consists mainly of aquatic animals, the stork *frequents* well-watered districts.

2. The food is gathered up from the ground, or picked off from low-

Digitized by Google

growing plants (snails and insects), or out of the water. The legs are strong, and, being articulated near the middle of the body (see ostrich), enable the bird to stride about for hours without fatigue.

3. The legs *are of unusual length*, the tarso-metatarsus and a portion of the lower part of the tibia being *naked* (wading legs). These arrangements enable the bird to wade to a considerable depth in the water, and to traverse shallow ponds or pools without wetting its plumage.

4. It also strides with ease over soft marshy soil, for the *posterior toe* touches the ground in its entire length (compare, on the other hand, the domestic fowl), whilst the surface of support is further increased by short webs connecting the *three broad anterior toes*, and extending to their tips in the form of narrow fringes. (Compare these structures with snow-shoes and the sledge-like contrivances used by people engaged in shore-fishing, when visiting the mud flats at low tide.) The toes being weak and their claws blunt, they cannot (as in raptorial birds) be employed as prehensile organs.

5. In spite of the great height of the legs, the *long neck* enables the bird to approach the *beak*, which is also of considerable length, to the ground. (Why is this necessary?) With the beak the stork picks up its food, which it then, by raising its head, allows to drop down its throat. It is able to kill animals of fairly large size, and to hold fast slippery creatures like frogs and fishes, the beak being *strong* and provided with *sharp cutting edges*.

6. At the beginning of the cold season the animals which form the food of the stork either enter upon a hibernating sleep or retire into sheltering retreats. The bird is then obliged to *migrate* to the warmer shores of Africa, where waters do not freeze and food is always abundant. Its *long wings* equip it for the distant voyage, and though the *short tail* is of little use as a rudder (compare with swallow), this deficiency is compensated by the long legs, which are extended backwards during flight, and serve as rudder to the feathered air-ship.

The Black Stork resembles the common stork in all respects save that the plumage, with the exception of the white under surface, is of a glossy brownish-black. It nests on high forest trees, far from human habitations. In Germany it is much rarer than its white relative.

Family 2: Herons (Ardeidæ).

The Gray or Crested Heron (*Ardea cinerea*).

(Length about 3 feet.)

This bird in shape of body strongly resembles the stork (compare the two birds); and though it does not despise as food any of the animals

Digitized by Google

consumed by the last-named species, it lives principally on *fish*, and is an adept in the art of catching this kind of prey. (Compare the heron and the kingfisher.) Hence it takes up its *abode* in districts well supplied with pieces of clear (why?) water well stocked with fish. In company with many others of its species (heronries), the bird constructs a rough nest (in which the young abide for some time after birth) in the trunks of high forest-trees. When engaged in fishing, the bird may be seen standing motionless "like a statue" in shallow water close by the bank, or slowly and noiselessly striding about in the water. (Why?) The *feet* are constructed on the same plan as those of the stork. The claw of the middle toe is dentated at its inner edge, and is used like a comb for cleaning and arranging the feathers. Its *plumage*, which is white below and bluish-grey above, renders it not easily distinguishable either by the fish which form its prey or by birds of prey circling above it. (Compare with the common frog and the carp.) The feathers at the back of the head and the lower part of the neck are elongated. On espying a fish (very sharp *eyes*), the bird seizes it with its long, laterally-compressed *beak*, which is darted forward with lighting-like rapidity by the long recurved neck. The sharp cutting edges of the beak, which are in addition finely dentated towards the tip, render escape impossible, however slippery the fish may be. The food is conveyed into the wide *throat* by the head, which is extended forwards in the operation. (Why?) The nostrils can be closed by a membrane. (Why?) In the autumn the heron *migrates* to the South. (Why?) It *flies* in the same manner as the stork, but with its neck drawn up against the body. It is an extremely voracious bird, very cunning and cautious, and therefore deservedly the object of incessant persecution.

The **Bittern** (*Botaurus stellaris*) is a closely related species. It lives among reeds, where its inconspicuous plumage (yellowish, with many black spots and streaks) makes it difficult to distinguish. On the approach of any danger the bird assumes a most peculiar protective attitude: it squats down on its heels, erects its head and beak, and by depressing its feathers close against the body acquires so thin a shape as to look more like a stake or a bundle of dry reeds than a living bird. At the beginning of the pairing season the male gives utterance to a peculiar sound resembling the lowing of cattle, and audible for a considerable distance.

At one time the bittern was a native of England; but the draining of the fens and swamps, and the progress of cultivation, have caused it to become extinct. Occasional specimens visit this country in winter and spring.

Digitized by Google

Family 3: Snipes, etc. (Scolopacidæ).

The Woodcock (*Scolopax rusticola*).

(Length 12 inches.)

The woodcock lives on the ground in woods. The *plumage* so closely approximates to the colour of the soil that the bird, when squatting among dry leaves next to a piece of bark or a projecting root, cannot be discerned even by the experienced eye of the sportsman. Places like this the bird accordingly selects to rest in. The *nest*, which is devoid of workmanship, is placed among dry leaves on the ground (young "precocious"), and the eggs display the same protective colouring (pale earth-coloured, with reddish and brownish spots). On the ground, too, the bird finds its *food*, which consists of slugs, earth-

Woodcock. (About one-sixth natural size.)

worms, insects and their larvæ. With the first melting of the winter snow the woodcock return from their winter quarters (why are they migratory birds?), to enjoy the feast which reawakening Nature so richly spreads for them. In Germany, the third Sunday in Lent—"Oculi" Sunday—is said by sportsmen to mark the arrival of the woodcock, as expressed in the rhyme, "Oculi—da kommen sie" ("Oculi—there they come"); only a few, however, remain, the majority "travelling" farther on to the Northern countries of Europe (passage of the woodcock). With the approach of dusk the bird emerges from its hiding-place, for the woodcock is a nocturnal bird (colour, compare with owls), and rummages among the foliage, feeling for food with its long beak. It uses

Digitized by Google

the beak, however, for another purpose, pushing it up to its base into the soft soil, and either pulling out worms with it or frightening them out of the earth by the concussion. The beak has a highly peculiar structure, corresponding to this peculiar mode of use. Being very long and thin, it can be pushed deep into the soil without difficulty, and the horny tip of the upper mandible envelops the edges of the tip of the lower, so that vegetable fibres cannot get between the two mandibles, and thus obstruct the boring action of the beak. Apart from the horny tip, the beak is comparatively soft; consequently, the upper mandible can be so bent as to form, with the lower, forceps for drawing out the prey. Hard ridges of horn, three on the upper, four on the lower mandible, give the firmness necessary for the boring function, and numerous tactile corpuscles over the tip of the bill enable it to be used in the same fashion as the probe with which the physician explores a wound. In fact, the beak of this bird is one of the small miracles of Nature. While probing with its beak the woodcock is, nevertheless, able to keep a lookout for what goes on around it, for the *eyes* are *large* (nocturnal animal), and are placed remarkably high up in the head. On account of this boring habit, the bird exclusively frequents woods where the *soil is soft and loose*. There are no membranes between the toes, the posterior of which (hallux) is small, and articulated at a higher level than the other two. (Compare with stork.)

Allied Species.

The **Common Snipe** (*Gallinago media*), like its relative the woodcock, is much pursued on account of its delicate flesh. It inhabits marshy localities. The male at the beginning of the pairing season gives utterance to a peculiar sound, which bears a striking resemblance to the "bleating" of a goat, and in Germany has gained the bird the title of "sky goat" (*Himmelsziege*).

A very peculiar member of this family is the **Ruff** (*Machetes pugnax*), which inhabits damp lowlands, and especially the seashore. Its plumage is inconspicuous, and resembles that of the soil. After the spring moult the male acquires a peculiar collar or ruff, consisting of large, strong feathers, and serving as a shield in the contests which the bird engages in with other males of its species. Little blood, however, is shed at these encounters, the beak being soft, and the face covered with warty excrescences. In the autumn the ruff and facial warts disappear again, and the male now completely resembles the more peaceful female.

Digitized by Google

Family 4: Plovers (Charadriidæ).

The Peewit, or Lapwing (*Vanellus cristatus*).

(Length 13 inches.)

With the disappearance of the last remains of the snow, the familiar "pee-wit, pee-wit" (hence the popular name of the bird) of the lapwing is heard in our *meadows*, and the birds career over the reawakening earth in all kinds of wonderful evolutions. The lapwing is a *handsome bird:* its upper surface is resplendent in greenish and purple metallic tints, while the black colour of the throat is in beautiful contrast against the white of the neck and under surface; the head bears an erectile tuft of feathers. The food of the bird consists of worms, insects and their larvæ, which it seeks while rapidly running along the ground. By its steps, which follow each other in rapid succession, it frightens the worms out of their holes; these are forthwith seized in its short *beak* and consumed. The *nest*, which displays little or no workmanship, is constructed out of a few stalks of straw on the higher parts of the ground (as a protection against floods). (The young are "precocious.") It lays four *eggs*, which are pear-shaped, and by their colour, which resembles that of the ground (green, with brown and black spots), are protected against nest-plunderers; while the birds themselves will pluckily defend the nest against human despoilers, the eggs being much sought after on account of their delicate flavour.

Family 5: Bustards (Otididæ).

The Great Bustard (*Otis tarda*).

(Height 30 inches.)

In its structure and mode of life this member of the "wader" order displays certain resemblances to the gallinaceous birds. It *inhabits* unfrequented, fertile, and level districts throughout the whole of Europe and Central Asia. The plumage is brownish above, sprinkled with numerous black spots and dots; the head, neck, and under surface are lighter coloured. (Compare with partridge.) The throat of the male is provided with a beard of long, loose-barbed feathers. The *wings* are short and rounded off (compare with domestic fowl), rendering this handsome bird but a very indifferent flier. Its deficiency in this respect is, however, amply counterbalanced by its speed in running, a dog being able only with difficulty to overtake the bird. For this faculty it is equipped with long, strong *legs*, which are furnished with strong toes

Digitized by Google

(the posterior toe—hallux—is absent. Compare with ostrich.) Its *food* is identical with that of the partridge, whence the beak, as in gallinaceous birds, is short and strong.

Family 6: Rails, etc. (Rallidæ).

The Common Coot (*Fulica atra*).

(Length 18 inches.)

This familiar bird is found throughout the whole summer (migratory bird—why?) on all the larger *ponds* and *lakes* of Europe the banks of which are bordered by reeds and rushes. The coot is not a regular migrant in England, though it moves southward when northern waters are frozen. Many winter on our South Coast, as at Slapton Ley in Devonshire. The *plumage* is black, and there is a glossy white horny plate (shield) on the forehead, the beak being of the same colour. It is constantly engaged in *swimming* and *diving*, and, indeed, lives in all respects like a typical swimming-bird (which see). The front-toes are very long, and fringed with notched membranous lobes, thus functioning as excellent oars. The bird lives on all sorts of vegetable substances and aquatic animals. It cannot, however, like the duck, burrow with its beak in the bottom of the water (the beak being short, narrow, and not provided with horny lamellæ).

Allied Species.

The **Moorhen** (*Gallinula chloropus*) (explain the name) is also a frequent inhabitant of ponds, pools, and ditches. On account of the small size of its habitation, its skill in hiding itself stands it in good stead. On the approach of danger it hides in the reeds or dives under water, allowing only its head, which is concealed among the reeds, to project. Frequently also it holds on to plants under the surface of the water, or hides itself under the leaves of the water-lily.

During the nights of spring we may frequently hear in meadows and fields the rattling call of the **Landrail** or **Corncrake** (*Crex pratensis*).* It resembles the quail in the earthy colour of its plumage, but is easily distinguished by its long wading legs.

* In Germany it is known under the name of "king of the quails" (*Wachtelkönig*), from a popular belief that it holds sway over these birds.

Digitized by Google

(Family 7: Cranes Gruidæ).

The Common Crane (*Grus cinerea*).

(Height 4 feet.)

Large *flocks* of this, one of our largest birds, may often be seen on the Continent travelling overhead in spring and autumn; frequently only their loud "groo, groo!" during the night announces the passage of the migratory hosts high up in the air. The flocks in their passage always arrange themselves in the form of a wedge, an arrangement which facilitates movement through the air, and, further, allows each individual bird an unimpeded view of its surroundings. One of the stronger birds always acts as leader at the apex of the wedge, and is relieved from time to time by one of its fellows. In its *shape*, the crane bears some likeness to a stork, and also resembles it in its *mode of life*. The plumage is of a beautiful light gray colour, and is distinguished by the fact that the wing-coverts are elongated and curled (ornamental feathers). The bird, which is intelligent and shy, nests in remote *marshy and swampy localities* in Scandinavia, North and East Germany, Russia and Siberia. The *female while incubating the eggs* smears its back over with the dark marshy soil to prevent its light-coloured plumage from betraying its presence. At one time the crane bred in Britain; now it is a rare visitor.

ORDER XI.: DUCKS (LAMELLIROSTRES, OR ANSERIFORMES).

Beak covered with a soft skin, except at the tip, which is hard; the edges of the bill furnished with horny transverse plates. Legs short; anterior toes united by webs (swimming-feet). Aquatic birds. Young "precocious." (Forming with the three following orders the division of natatorial birds.)

The Wild Duck, or Mallard, and its Descendant, the Domestic Duck (*Anas boschas* and *A. domestica*).

(Length 25 inches.)

Our domestic duck is the descendant of the wild duck, a species which is met with throughout the whole Northern Hemisphere. (Why has the duck been domesticated?) In spite of a domestication extending over some hundreds of years, the duck has not laid aside the habits and

Digitized by Google

mode of life of its primitive wild ancestor, for, like the latter, it is a true *aquatic* bird, which spends hours and whole days in the water. There we may meet it in the winter, too, swimming about even among drifting ice, for—

A. It is able to defy the Cold of the Water.

1. The *plumage* of the duck on the breast and belly is distinguished by the great quantity of down-feathers, and by the possession of rigid contour-feathers (compare, on the other hand, the owl), which fit closely over the under-garment of down. These contour-feathers are arched, in order to form a more effective covering for the down-feathers. By these arrangements a large number of firmly-closed air-spaces are formed between the feathers, which markedly diminish the loss of body-heat on the one side, and on the other prevent the access of cold water to the body-surface. The cooling of the latter is further prevented—

2. By careful *oiling* or *preening* of the contour-feathers. By the aid of its broad beak the bird squeezes an oily fluid from the ducts of the uropygial gland, which open between the shafts of the tail-feathers, and then, oiling each of the contour-feathers by drawing it through its beak, makes them waterproof. Why has this process to be frequently repeated?

3. The duck possesses a second means of protection against cold in the presence of a *layer of fat* below the integument, with which we are all familiar in the bird when served on the table (as also in the goose; compare with seal).

4. The *feet, which are naked,* contain so little blood that no considerable cooling of the total quantity of the blood results from their immersion. (Imagine, on the other hand, a man wading in winter through ice-cold water.)

B. The Duck ploughs its Way with Ease along the Surface of the Water (Swimming-bird).

i. Why it does not Sink.

A swimming mammal sinks in the water to such a depth as only to leave its head exposed. The duck, on the other hand, swims on the *surface* of the water, only the lower portion of its body being immersed; indeed, it can remain in this position while *at rest;* this is due to the fact that

1. The body-weight is much reduced, owing to the presence of *air-sacs* (see p. 145), the *hollowness* of the bones and feathers, *the air-spaces between the feathers* (compare with a cork), and the *subcutaneous fat layer.* (Compare with seal.)

Digitized by Google

2. The *body* being broad and flat, thus presenting a broad surface to the water, the bird is supported more steadily than if its body were cylindrical. (What might easily happen in the latter case?)

ii. Its Manner of Progression by Swimming.

1. In its *feet*, the long front-toes of which are united by webs, the duck possesses oars (compare with otter) which are moved in alternation (natatorial feet). The expansion of the webs in the backward stroke and their folding up in the forward movement are carried out involuntarily, as in the toes of a bird settling on a branch (see p. 143). This may be easily observed in the bird while walking, since its walking and swimming are essentially similar movements.

2. Inasmuch as only the *feet project from the body, and the leg* (tarso-metatarsus) is *short*, these oars can execute powerful strokes against the resistance of the water (see seal).

3. The *sharp anterior edge of the leg* (tarso-metatarsus) cuts the water with ease.

4. The legs are moved by powerful muscles.

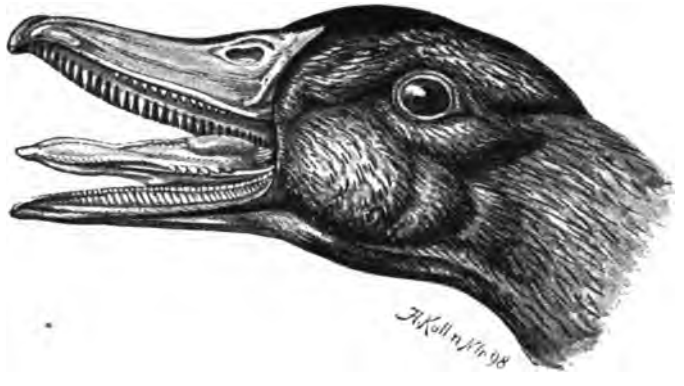
5. The legs perform the part not only of oars, but of rudder. The body of a duck may therefore be likened to a boat which is propelled, and at the same time steered, by an oarsman with two oars. Now, as the point on which such a boat turns is located in the seat of the oarsman, the latter, instead of placing himself in the middle of the boat, sits as far back as possible; for in this case the fore-end of the boat is made to describe a wider deviation—*i.e.*, the steering has a greater effect. Accordingly, in the duck, too, the *oars are articulated to the body far behind*. For the same reason, in those swimming-birds whose life is passed to a still larger extent on or below the water, the legs are articulated still further behind (*e.g.*, swans), or even quite at the posterior end of the body (*e.g.*, the great crested grebe and penguin).

Though a skilful swimmer, the duck's progress *on land* is awkward and ungainly. The tibia lies completely within the body, and hence only slightly shares in the motion of the legs (compare, on the other hand, the ostrich and stork); the tarsus, moreover, is short; all these arrangements impart a certain stiffness to the gait of the bird. (In what other birds is this the case? Name the different joints at which the human leg is bent in walking. Endeavour to walk without bending the knee-joint.) Further, the articulation of the legs far apart from each other causes the duck to waddle. (Compare, on the other hand, the stork and ostrich.) The webs of the feet also impede walking.

Digitized by Google

C. The Food of the Duck is chiefly obtained in the Water.

It consists of molluscs, worms, aquatic insects and their larvæ, occasionally also amphibians and small fish, all kinds of water-plants ("duckweed") and the animals, spawn of molluscs, etc., attached to them. The bird also visits meadows and fields, and consumes all kinds of seeds and grain, grass and young crops. The tame duck, though fed by its keepers (what with?) nevertheless prefers to find animal food for itself in the water. Aquatic animal life, however, is always more abundant by the *banks* of a pond or stream, *among the reeds*, than in the open water, and in *shallow pieces of water* more so than in deep ones. (Demonstrate this by drawing a net of fine gauze through the water, and then turning out its contents into a vessel of water.) Accordingly, the duck is most frequently met with in places of this description.



Head of Wild Duck.

1. Its long neck enables it to immerse its beak to a fair depth, and to rummage about in the mud at the bottom of shallow pieces of water.

2. In doing this the bird also immerses the anterior part of the body, and consequently appears as though it "stood on its head." It is enabled to assume this position owing to the *centre of gravity of the body being placed far forwards* (position of legs), which facilitates the tipping over of the body in a forward direction.

3. (*a*) The upper half of the beak is covered with a *soft skin*, which in front is provided with numerous *tactile corpuscles*. (The subjacent bones at this portion of the beak are perforated like a sieve, the perforations being traversed by the nerves which terminate in the tactile papillæ.) By the help of this tactile apparatus the duck is able to find its food even in turbid water and in the mud. (Compare with snipe, mole, and bat.)

Digitized by Google

(*b*) *The edges* and *the hooked tip of the bill* are horny, and adapt the beak for cutting off aquatic plants and for holding fast prey of a slippery description (amphibians, fishes).

(*c*) The outer edges of the lower and the inner edges of the upper beak are furnished with numerous leaf-like horny plates or lamellæ, which, when the beak is closed, interlock with each other. (The upper beak is broader than the lower beak.)

(*d*) The tongue is large and fleshy, and provided at its edges with horny fringes. By these arrangements

(*e*) The *beak*, which, moreover, is *broad and flat*, is converted into a perfect "strainer." (Compare with whale and herring.) When a portion of mud has been taken up, the water is forced out by the tongue, and flows out over its fringes and through the grooves at the edge of the beak, so that only the solid portions are retained. The tongue, being endowed with a fine tactile sense, then separates the eatable constituents from the uneatable portions. (Why does the duck, "the pig among birds," sift the mud of pools and gutters?) Swimming animals, however small, are captured in the same manner.

4. The duck possesses a *muscular gizzard* like the fowl, and, like the latter bird, takes in sand and pebbles with its food.

5. When the ponds and lakes become covered with ice, the wild ducks *migrate* in large flocks to the South. The few which remain betake themselves to rivers and streams, and if these freeze they also are compelled to take their departure.

D. Enemies.

The duck is zealously pursued by the sea-eagle, the goshawk, sparrow-hawk, and other birds of prey, as well as by the otter and marten, while many of the young also fall a prey to rats and crows. Its chief enemy, however, is man, who hunts it for the sake of its palatable flesh.

1. The *water and reeds* amidst which it lives afford it good protection. (Say which of its enemies are incapable of pursuing it into such places.)

2. When surprised by birds of prey, it seeks to escape by *diving*.

3. Their greyish-brown, dark-spotted, *inconspicuous plumage* serves to hide female and young to a considerable extent among the reeds; they are also clever at "ducking" on the approach of danger. The "breeding plumage" of the male in the later part of the winter and in spring is very handsome, the head and upper part of the neck being of a beautiful metallic greenish-blue colour, with a white band on the lower throat; the breast is chestnut brown; the wings are ornamented with a beautiful blue white-edged spot—the so-called speculum. (What are the colours of the

Digitized by Google

tame duck? Why have many of these no protective colouring, like their wild ancestors? (See cat.)

4. The duck is *a very prolific bird.* (Compare with hare.) The female deposits from ten to sixteen eggs in a carelessly constructed nest, concealed in some safe hiding-place and softly lined inside with the bird's own down. When she leaves her nest in search of food she covers the eggs, which are pale-greenish, and thus not protectively coloured, with leaves and blades of grass, of which the nest is constructed. The young are "precocious," and follow their mother into the water immediately after leaving the egg.

Allied Species.

A large number of duck species are found in Europe, especially along the seacoast, all of which in structure and mode of life almost completely resemble the wild duck.

The **Eider Duck** (*Somateria mollissima*) is of frequent occurrence on the coasts of the Northern seas both in the Old and New World. The down-feathers with which the nests are lined are much esteemed on account of their lightness and elasticity.

The **Grey Lag Goose** (*Anser cinereus*), the ancestral form of our domestic goose, inhabits Northern and Central Europe; in Germany it at present is only met with in the north and east. Formerly the wild goose bred in Lincolnshire, but now its breeding-places in the British Isles are limited to the North of Scotland and the Hebrides. It is scarcely distinguishable from a grey domestic goose. Its food consists chiefly of water-plants, which it cuts off with the sharp edges of its beak. Its legs being taller and articulated nearer the middle of the body render it better adapted for walking than the duck. In spring and autumn large flocks of these birds, arranged in the form of a **V** (see crane), may frequently be seen overhead on their migration flight. (What are the uses of the domestic goose? Compare it with the duck.)

The **Mute Swan** (*Cygnus olor*), distinguished by a knob on the bill, is much kept as an ornamental bird on ponds. The home of this handsome, snow-white bird is in the Northern parts of the Old World. Wild specimens occasionally visit Britain in winter. The bird leaves the water with reluctance, and its walk on shore is even more ungainly than that of the duck, owing to its legs being articulated very far backwards. Its long neck enables it to forage at the bottom of fairly deep water.

The **Flamingo** (*Phœnicopterus roseus*) is a distant relative of the duck. It is a peculiar bird which, on account of its unusually long wading feet, is sometimes classed with the waders; while others, from

Digitized by Google

the structure of its beak and feet (perfectly webbed) place it among the swimming-birds. It is found often in large flocks on the coasts of the Mediterranean. Standing in shallow water, the bird shovels up the mud with its feet, and then pokes about in it after the manner of a duck, seizing in its beak, which is curved downwards from the middle, and lamellate, such crabs, snails, or worms as it may have disturbed from their concealment. At the same time the bird bends its neck in such a manner that the spoon-shaped upper beak, with which it scoops up its prey out of the water, comes to lie downwards. In shallow waters it builds a nest out of mud and vegetable remains. This nest is conical and raised above the surface of the water, and the bird sits on it in the manner of all long-legged species, with its legs doubled up under its body. The plumage is of rosy colour, with the exception of the flight-feathers, which are black.

ORDER XII.: PELICAN-LIKE BIRDS (STEGANOPODES).

Beak usually long; the halves of the lower mandible united by a naked skin. The hind-toe (hallux) directed inwardly. All the toes united by webs (swimming-feet). Aquatic birds. Young helpless.

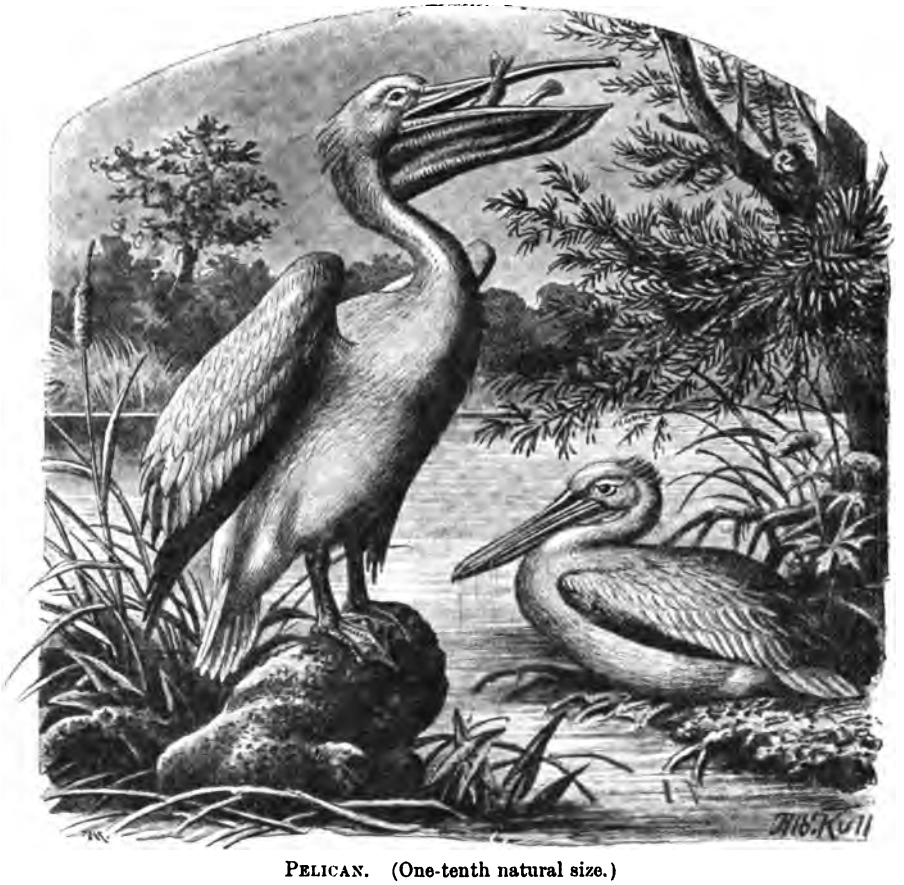
The Common Pelican (*Pelecanus onocrotalus*).

(Length up to 6 feet.)

The range of the pelican extends from Southern Hungary over a large part of Africa and Southern Asia. It is natatorial in its habits (see duck), and in shape somewhat like a goose, from which, however, apart from the structure of its feet (see above), it is essentially distinguished by its long and peculiar bill. Between the two flexible halves of the lower mandible is stretched a very extensile membrane or "gular" pouch, so that the structure is not unlike a fisherman's landing-net. A fish having been scooped out of the water by means of this natural net, the upper beak covers it like a lid. The mandible is now pressed firmly against the hooked prolongation of the upper beak, whereby its branches are deflected to some extent. Through the gaps thus formed the water flows out of the net, while the fish is forced down into the wide throat. The pelican is unable to dive, and is therefore restricted to fish exclusively in shallow waters. (Why?) The birds always fish in companies, a number of them forming a circle and then gradually approaching towards the centre, or they arrange themselves in a semicircle and drive their prey towards the shore. The pelican is the symbol of self-sacri-

Digitized by Google

ficing maternal affection, for, according to a popular legend, the female, in case of need, tears open its breast in order with its own blood to appease the hunger and thirst of its young.



PELICAN. (One-tenth natural size.)

ORDER XIII.: LARIFORM BIRDS (LONGIPENNES).

BILL laterally compressed, hooked at the tip. Wings very long and pointed. Feet webbed (natatorial; see p. 216). Aquatic habits. Young helpless.

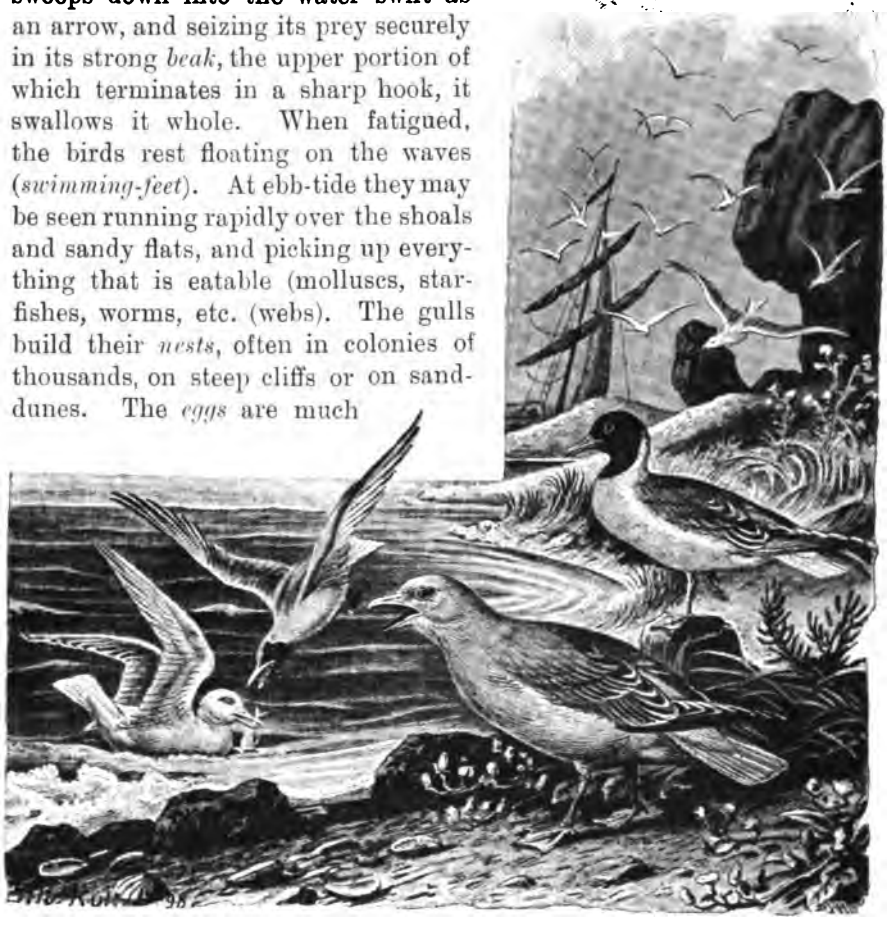
The Herring Gull (*Larus argentatus*).

(Length 26 inches.)

The herring gull inhabits almost all the coasts of the Northern Hemisphere. In the North Sea it is one of the commonest of the

Digitized by Google

numerous species of gulls to be found there. Its yellow beak, the pale red feet, the snowy white plumage, blue-grey above, render this bird a true *ornament of the sea*. Its *food* consists principally of fish. By its long pointed *wings* the bird is adapted for rapid and remarkably dexterous flight. Having espied a fish with its sharp *eyes*, the bird swoops down into the water swift as an arrow, and seizing its prey securely in its strong *beak*, the upper portion of which terminates in a sharp hook, it swallows it whole. When fatigued, the birds rest floating on the waves (*swimming-feet*). At ebb-tide they may be seen running rapidly over the shoals and sandy flats, and picking up everything that is eatable (molluscs, star-fishes, worms, etc. (webs). The gulls build their *nests*, often in colonies of thousands, on steep cliffs or on sand-dunes. The *eggs* are much



HERRING AND BLACK-HEADED GULLS.
The bird in the foreground is a herring gull, that in the background a black-headed gull, about one-tenth natural size.

sought after, having an agreeable flavour; they strongly resemble those of the lapwing, and are, in fact, often fraudulently placed on the market as plovers' eggs.

Digitized by Google

Allied Species.

The **Black-Headed Gull** (*L. ridibundus*) is most frequently met with on inland waters. It is only about the size of a crow, and in the colour of its plumage resembles the herring gull, with the exception of the head, which is dark brown in summer, but white in winter.

The **Albatross** (*Diomedea exulans*) belongs to this order. Its body measures over 3 feet in length. It breeds on the solitary islands of the Southern Atlantic and Indian Oceans. It is the true monarch of the ocean, being able to fly for days long without even once taking rest upon the waves. It allows itself, in fact, to be driven along by the wind, using its wings as sails (soaring flight).

ORDER XIV.: DIVERS (IMPENNES).

Beak laterally compressed. Wings very short; legs also very short, articulated to the body very far back. The webs of the feet often deeply incised (cleft-webbed feet). Aquatic in habit. Young either helpless or "precocious."

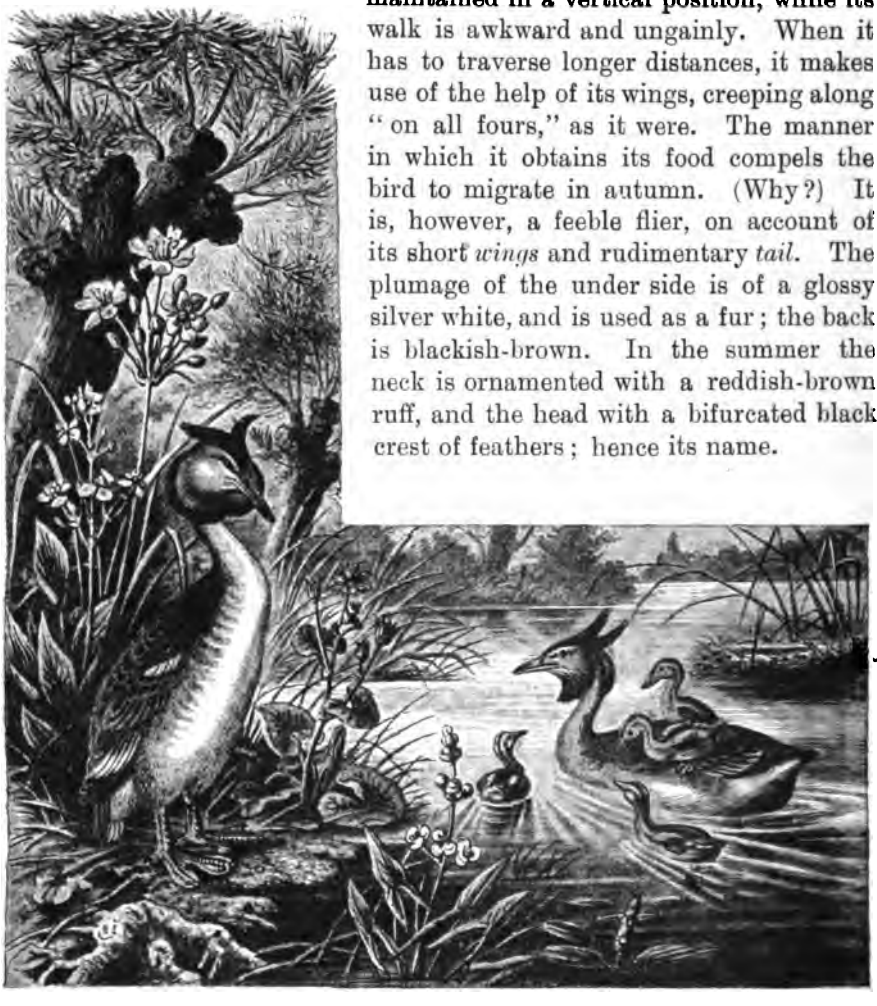
Great Crested Grebe (*Podiceps cristatus*).

(Length 26 inches.)

This curious bird is even more typically a *denizen of the waters* than the species described above. It is met with on all the larger lakes of Germany, and in England breeds on the Norfolk Broads and certain other lakes in the Northern counties. It never leaves the water unless actually compelled, and even sleeps on the surface. The eggs, too, are hatched in a nest which floats on the water attached to rushes. On leaving it, the bird covers over the *eggs*, which are white (devoid of protective colouring), with some of the materials of which the nest is composed, so that the latter now assumes a striking likeness to a heap of water-plants drifted together. The *food* of the bird consists of aquatic insects, amphibians and their larvæ, but especially fish, which it catches by swimming and diving. For these actions the bird is excellently adapted by the following features: the heavy, elongated body, which is richly supplied with fat; the close, well-oiled *plumage;* the short *legs*, which are placed almost at the extremity of the body, and in which the tarsus is strongly compressed from side to side, whilst the three front toes are united by deeply-incised webs. (Compare with duck.) This bird can accomplish a distance of about 130 yards per minute when diving under water. Its straight, sharp-edged *beak* is excellently adapted

Digitized by Google

for retaining a firm hold of its slippery prey. In consequence of the legs being articulated so far behind, the body of the bird whilst sitting is maintained in a vertical position, while its walk is awkward and ungainly. When it has to traverse longer distances, it makes use of the help of its wings, creeping along "on all fours," as it were. The manner in which it obtains its food compels the bird to migrate in autumn. (Why?) It is, however, a feeble flier, on account of its short *wings* and rudimentary *tail*. The plumage of the under side is of a glossy silver white, and is used as a fur; the back is blackish-brown. In the summer the neck is ornamented with a reddish-brown ruff, and the head with a bifurcated black crest of feathers; hence its name.



FAMILY OF GREAT CRESTED GREBES.
The male standing on the bank about one-tenth natural size.
N., Floating nest.

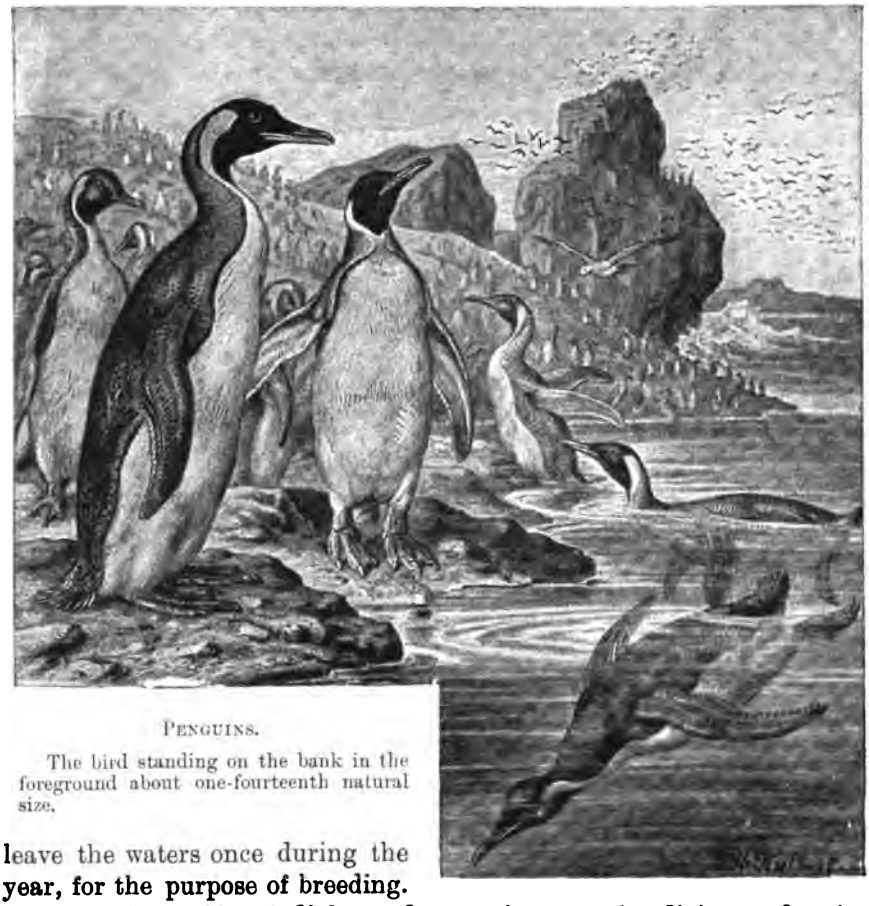
Allied Species.

The **Little Grebe** or **Dabchick** (*P. minor*) is also of frequent occurrence in Germany and England. The bird is about the size of a partridge, blackish-brown above and greyish-white below.

Digitized by Google

The **Auks** (*Alcidæ*) and the **Guillemots** (*Uriinæ*) are diving birds similar in structure to the above, and inhabiting the North Atlantic. Their food consists of fishes, crabs, and other marine animals, which they capture by diving. At the breeding-times they congregate in innumerable flocks on steep cliffs.

The **Penguins** (*Spheniscidæ*) represent "the fish among birds." They inhabit the inhospitable seas around the South Pole. The birds only



PENGUINS.

The bird standing on the bank in the foreground about one-fourteenth natural size.

leave the waters once during the year, for the purpose of breeding. They are incapable of flight, and move in water by diving and swimming, in pursuit of fish, using their fin-shaped wings as oars. The body is protected against the icy cold of the water by large masses of fat (see seal), while the feathers, which lie close against the body, are well soaked in oil (see duck). In some species the feathers of the back and of the upper surface of the wings even assume the form of scales.

Digitized by Google

CLASS III.: REPTILES (REPTILIA).

VERTEBRATE animals whose body temperature varies with that of the external medium; the body covered by horny or bony plates (scutes); breathing by lungs, and generally oviparous; limbs in the form of legs or absent.

1. The **Shape of the Body** in reptiles (explain the name) is very variable. The typical forms are those of the lizard, the snake, and the tortoise, which are repeated with more or less variation in the different orders.

2. **Limbs.**—Either one or two pairs are present or they are entirely absent. (Examples.) In the perfectly-developed limb the constituent bony elements are the same as in mammals (see Part I., p. 12). In proportion as the limbs are reduced in size the body becomes more elongated, and either aids in or entirely takes over the business of locomotion (see lizards and snakes). The different ways in which reptiles move explain the different relations of

3. **The Skeleton.**—(*a*) Those species in which the limbs are well developed possess both the shoulder and pelvic girdles (see Part I., pp. 4 and 11). In species devoid of hind-limbs the pelvis is absent, or only persists in a very rudimentary condition. In the snakes the shoulder girdle also is absent. (Give reasons for these differences.)

(*b*) The *vertebral column* in those species which possess limbs is, as in mammals, divisible into several segments. In limbless species, on the other hand, it consists of a uniform series of similar vertebræ. Their number varies directly with the length of the body (more than 400 in some snakes), as does also their mobility. (Why? See lizards and snakes.) In the tortoises the vertebræ are in part anchylosed with the dorsal carapace. Ribs are present in varying number, and in the snakes (which see) aid in locomotion.

(*c*) The *skull* in its general structure is like that of birds. As in the latter, a quadrate bone is present. Where this bone is united to the mandible by ligaments only (lizards and snakes), the mouth can be

Digitized by Google

widely distended. In the snakes, moreover, the facial bones are very movable. (Why? See under snakes.)

4. **Body Temperature.**—The body heat (see Part I., p. 7) of reptiles is considerably lower than that of birds or mammals. This is due to the fact that—

(*a*) *Respiration* and (*b*) the *circulation of the blood* proceed much more slowly than in the last-named classes. We know, however, that in proportion as an animal breathes more rapidly and deeply, more oxygen is conveyed to its blood, and that combustion (production of heat) goes on more actively in proportion as the rapidity of the circulation increases. To this must be added the important fact that the two *ventricles of the heart* are not completely separated (in the crocodiles alone is this separation perfect). Consequently, the arterial is mixed with the venous blood, so that it is never pure (free from carbonic acid gas), and carries less oxygen to the different parts of the body than is the case in warm-blooded animals.

(*c*) With a slowly-proceeding combustion, the quantity of fuel required by the animal machine is inconsiderable (see Part I., p. 8). Reptiles accordingly need a much less *amount of food* than warm-blooded animals. In relation with this, again, is the imperfect development of the organs of locomotion in reptiles, and the general sluggishness of all their movements as compared with the higher vertebrates. (If a reptile required the same amount of warmth, and consequently of food, as a bird or mammal, it would soon perish, in consequence of its inferior powers of locomotion.) With the diminished food requirements of reptiles we must further connect such facts as their strong need of repose, their tolerance of prolonged fasting, their ability to live for a long time without breathing, as well as the feeble mental faculties noticeable in all the members of this class. Indeed, in comparison with mammals and birds, reptiles may be said to be leading only "half a life."

(*d*) From the two last-named classes of vertebrates, reptiles (as well as all other animals) differ as regards their body temperature in one other important point. It is well known that in birds and mammals the vital activities are seriously endangered whenever the temperature of their body falls much below or rises above the normal. In *reptiles, on the other hand, the vital activities are not restricted to a definite temperature of the body.* Their temperature, in fact, rises and falls with that of the air which surrounds them, or of the water or soil in which they live. They are, in short, animals of *variable temperature* (or, less accurately, cold-blooded animals).

However, as is the case in all other so-called cold-blooded animals, with the rise of the temperature of the surrounding medium the vital

Digitized by Google

activity of reptiles increases, while it is lessened with the reduction of the outside temperature. As the temperature of the air rises, the respiration becomes more active, the blood courses more rapidly through the body, the demand for food becomes keener, digestion proceeds more rapidly, and all the movements of the body are accelerated. This explains the great love of sunshine displayed by reptiles, especially the more active species (*e.g.*, lizards), and their greater abundance in the warmer regions of the earth (as well as in earlier warmer periods of the earth's history). Reptiles thrive particularly in a dry atmosphere, though they are also able to live in a moist air. (Notice the advance they display in this respect, in common with birds and mammals, in comparison with amphibians and fishes.) With a decrease in the temperature of the air, however, these animals become more and more sluggish, until finally, in colder districts, they become quite torpid and sink into a hibernating sleep, from which they are only aroused by the reviving warmth of returning spring. *Thus the vital activities of reptiles vary with the annual changes of the external temperature.*

5. **Covering of the Body.**—Since the heat of the body is of no importance to reptiles, they are not, like warm-blooded birds and mammals, in need of special heat-preserving envelopes (hair, feathers, or fat layers). Their body covering serves principally as a protection against external injuries and against their drying up in a hot and dry air, though in some (lizards, and especially snakes) it also renders aid in locomotion.

The lower skin, or derma, is thickened locally, and hardened (*e.g.*, in most lizards) or ossified (*e.g.*, in chelonians). The epidermis covering these portions, which is shed and renewed periodically (*sloughing*), is likewise thickened and cornified. When these thickened portions are apposed by their edges they are termed *scutes*, but if they overlap each other, like tiles, they are described as *scales*. In many cases (especially in the crocodile) smaller or larger bony plates are developed in the deeper layers of the skin by the deposit of calcareous material.

6. **Dentition.**—All reptiles, with the exception of the chelonia, possess *teeth*, which are inserted in the mandibles, the maxilla, and in some also in the palate. They are all of similar conical shape (compare, on the other hand, with mammals) and directed posteriorly, being consequently adapted rather for holding the prey (see lizards and snakes) than for tearing it up or masticating it. In the crocodiles the teeth are fixed in sockets, while in lizards and snakes they are united firmly with the mandibles, maxillæ, and palatine bones. (For the poison fangs see viper.)

7. **Reproduction.**—Most reptiles propagate themselves by *eggs*, which

Digitized by Google

are covered in lizards and snakes with a parchment-like skin, in chelonians and crocodiles with a hard calcareous shell, and deposited in protected spots or in the earth. (Give examples.) They are hatched by the warmth of the air or soil. Some species, in which the eggs are retained so long in the body of the female that the young emerge from them before they are laid, are termed *viviparous*.

ORDER I.: LIZARDS (SAURIA).

Body elongated, sometimes vermiform, covered with scales or scutes; two pairs or one pair of limbs, or limbs entirely absent. A shoulder girdle always present. The bones of the face are not movable. Teeth not lodged in sockets. Eyes usually provided with lids.

The Sand Lizard (*Lacerta agilis*).

(Length about 8 inches.)

A. Habitat.

This harmless animal lives on hills covered with low shrubs, on stone-heaps, heaths, the edges of woods, dry ditches, and railway embankments—in fact, in all places well exposed to the sun's rays, *warmth being one of the necessary conditions of its life.** The lizard feels at its best when the summer sun sends its hottest rays down upon the earth and man seeks eagerly the cool shade (see p. 230). Rain and cold weather, on the other hand, it dislikes, and at such times creeps for shelter into holes in the earth. This dependence of the lizard on warmth explains—

B. Its Distribution.

Its range does not extend beyond Southern Sweden and the South of England. In Central Europe, on the other hand, it is to be met with in all suitable localities.

C. Colour.

The colour of its skin is very variable, and in a marked degree adapted to that of the ground which it frequents. Hence the ease and rapidity with which the animal escapes from sight when pursued in the grass. The skin of the female is always of an earthy colour (grey or brown, with several rows of white, brown-edged spots). In the male, on the other hand, a more or less vivid green tint usually predominates, which, however, is in no way conspicuous amidst the grass. The head

* In German *Eidechse*, *i.e.*, lizard, is equivalent to sun-worm.

Digitized by Google

is covered with scutes, the rest of the body with scales, those of the breast and belly being distinguished by their larger size and brighter colour. The latter, however, does not betray the animal's presence, as the scales in running are in contact with the ground. In the course of the summer the skin with the scales is peeled off several times in shreds by rubbing against stones, stalks, etc. Its inconspicuous colour forms an excellent protection to the animal against—

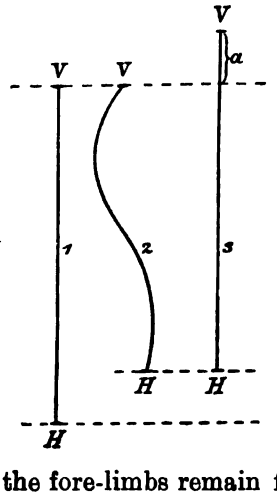
D. Its Enemies.

Among these we must place the smooth snake, the viper, the marten, falcons, crows, shrikes, etc. Against these this feeble animal is unable to defend itself, and its only escape lies in great caution and speedy flight (see Section E, 1 and 2).

E. Food.

The lizard is a predaceous animal. Its food consists of butterflies, moths, beetles, grasshoppers, crickets, flies, all kinds of insect larvæ, spiders, earth-worms, and small slugs.

1. The animal has acute *senses*. Its ear can detect the lightest rustle. The tympanic membrane is freely exposed and visible at the back of the head in the form of a small dark spot. The *eyes* are brilliant, and, as in birds, furnished with two eyelids and a nictitating membrane. The animal only takes notice of moving prey. The *tongue* is long, deeply forked at its end, and protrusible. It serves as an organ of touch, and by its aid also the animal drinks, for which purpose the tongue is moistened with dew or dipped into the water, and then drawn back into the mouth.



2. *Movements.*—(*a*) The lizard runs along the ground in jerks, rapidly and nimbly. The legs are short, weak, and directed laterally away from the body. By their aid alone the animal cannot execute its rapid forward movements. These, in fact, are accomplished by *undulating* movements of the whole body, the lower surface of which touches the ground. Let us assume the body to be stretched to its full length, as shown in line 1 of accompanying diagram (V represents the position of the fore, H of the hind, limbs). If while the fore-limbs remain fixed the body is bent towards the side, the hind-limbs will be drawn further forwards, as shown in line 2. If now the

Digitized by Google

hind-limbs are fixed and the body stretched out once more (line 3), it is brought forward by the distance *a*. The animal derives support in creeping by propping the scales on the under side of the body against any inequalities of the surface. From this manner of progression we can understand the length and the great mobility of the body of these animals (see vertebræ of snakes); while it becomes at once evident that the more the limbs of a reptile are atrophied, the more elongated its body needs to become. Hence limbless lizards (*e.g.*, the blind-worm) must of necessity assume the shape of a snake.

(*b*) The *tail* executes similar undulating movements, and consequently helps in pushing the body forwards. It, too, is accordingly very long and flexible. Its importance as an aid to locomotion is at once evident from the fact that lizards which have lost their tails are not able to run nearly as fast as unmutilated specimens. Moreover, the motions of such an animal become less steady, showing that the tail acts in addition as a sort of balancing-rod for the maintenance of equilibrium; while, finally, by forcibly striking the ground with its tail the lizard can execute wide and rapid leaps, which is of considerable advantage to it, especially in the capture of butterflies. If the tail is broken off when seized by an enemy, it grows again, but not to its original length.

(*c*) The *long sharply-clawed* toes enable the animals to climb nimbly and safely along rocks and on low bushes.

3. *Mouth.*—Such prey as has been captured while leaping and running, the lizard can only kill and crush with

(*a*) Its small teeth, which are placed in the jaws and palate (not lodged in sockets), and directed backwards (see snakes).

(*b*) The *gape of the mouth is wide*, as the prey has to be swallowed whole and unmasticated.

F. Reproduction.

The female in June lays from five to ten white eggs (about the size of sparrows' eggs) in the sands or between stones. They are hatched by the heat of the sun's rays, and the young emerge mostly in August.

For hibernation, see p. 230.

Other Lizard Species.

The **Common** or **Viviparous Lizard** (*L. vivipara*) is slightly smaller than the sand lizard. These two species never occur in the same localities, since the last-named species pursues and consumes the young of the common lizard wherever it can obtain them. Consequently the latter retires to places where it is beyond the reach of its inveterate foe

Digitized by Google

—to mountains, woods, moors, and in general more elevated and moister localities. The ground colour of this species is a more or less deep brown with darkish stripes and lighter coloured dots extending along the back and the sides of the body. It obtains its name *viripara* from the fact that the young leave the eggs before they are laid.

The beautiful **Green Lizard** (*L. viridis*) is a native of the countries of the Mediterranean, but is also found in the warmer parts of Germany (*e.g.*, in the valleys of the Danube and Rhine). In Southern countries it attains to a length of as much as 17 inches.

The **Wall Lizard** (*L. muralis*), an equally pretty but much smaller animal (length up to 9 inches), has the same range as the green lizard. Sunny walls and cliffs are its favourite resorts. In the warm sun it glides about with incomparable speed and nimbleness, and by the aid of its sharply-clawed toes can even climb up vertical walls. Its colour is very variable, but mostly brown or gray, like the ground which it frequents.

One of our most familiar species is the **Blind-Worm** or **Slow-Worm** (*Anguis fragilis*), a harmless animal, devoid of limbs, and moving after the manner of a snake. (Why is it not classed among the latter?) The body of this animal is covered with bony scales, which render its movements stiff and awkward as well as slow. (Hence the name slow-worm; the designation blind-worm, however, is a misnomer, and is due to the fact that in the dead animal the eyes are closed by the lids, which is not the case in a snake.) Active insects being accordingly beyond its reach, its food consists principally of earth-worms and slugs. As these animals mostly emerge from their holes at night or after rain, the habits of the slow-worm are also nocturnal, except in wet weather. Its colour resembles that of the soil or of dry herbage. On a peaty soil it is nearly black (protective colouring). It brings forth living young (see viviparous lizard).

Of the numerous lizards inhabiting warmer countries only a few will be mentioned. (Why are lizards far more numerous in warm countries?) The **Gecko** (*Tarentola mauritanica*) is met with on the shores of the Mediterranean on rocks, walls, and in human dwellings. Its length is about 6 inches, and its colour, corresponding to its habitat, varies from grey to brown. The most remarkable fact about this animal is that it is capable, contrary to the laws of gravity, of running about on vertical walls, and even the ceilings of rooms. The five toes, in fact, are widened out into discs, and are furnished below with transverse membranous lamellæ, which are imbricated—*i.e.*, cover each other like the slates of a roof. When these lamellæ are appressed to any object, a part of the air enclosed between them is driven out. When the pressure ceases, the lamellæ are erected, spaces containing rarefied air being thus formed between them,

Digitized by Google

so that the superior pressure of the external air presses the foot against the object with which it happens to be in contact. (Compare the suctorial discs of the cuttle-fish.)

A still more remarkable group are the so-called "flying lizards." The most familiar of these is the **Flying Dragon** (*Draco volans*) of the Sunda Islands. It lives in the densely-foliaged crowns of trees, and, like the birds of the tropical zone, is resplendent in all the colours of the rainbow. (What is the significance of this brilliancy of colour? Compare with parrot and humming-bird.) The animal is about 8 inches long, and on each side of the body possesses a parachute-like expansion formed by a fold of the integument and supported by ribs growing straight out from the spinal column through the body walls. By means of these parachutes the animal can swing itself obliquely from above downwards (why not in the opposite direction?) from branch to branch, a mode of locomotion which forms an excellent aid to it in the pursuit of insects.

Another peculiar member of this order is the **Chameleon** (*Chamæleo vulgaris*). This animal is a native of Southern Spain and North Africa, and reaches a length of about 12 inches. It is truly arboreal in habit, and on account of its variable colour is almost totally indistinguishable amid dense foliage. Its colour is subject to all sorts of changes, passing from green into blue, gray, brown, black, and all sorts of intermediate tints and combinations, as a result either of differences in the reflection of light, or of hunger, thirst, etc. (see p. 253, Section *d*). Indeed, the animal frequently bears more resemblance to some gnarled excrescence than to a living creature. The toes are perfectly adapted for climbing, being arranged, not side by side, but opposite each other (three against two), so as to form tongs for clasping and holding on to objects. (Compare with scansorial birds.) The legs are long, so that they can be placed one behind the other when the animal is clinging to a branch. (Compare, on the other hand, the sand lizard.) The long prehensile tail (compare with howling monkeys) acts as a fifth hand, as it were, and lends additional support to the animal's high and laterally compressed body. Clinging in this manner the animal will remain for days, motionless upon a branch, looking out for prey (insects). The eyes are spherical and covered with a single lid, perforated centrally by a circular opening in front of the pupil. These eyes can be moved quite independently of each other, so that the animal can look simultaneously in front and behind it, above and below, and is thus able to survey a large space in search of food. Being, however, extremely slow in its movements, the chameleon would have long to wait before it could capture a fly, beetle, or butterfly if its tongue did not provide it with a most singular instru-

Digitized by Google

ment of capture. This organ is long and vermiform, club-shaped in front, and can be protruded to half the length of the animal's body, with lightning speed. The tongue hits an insect with the utmost precision, the prey adhering to the club-shaped end, which is covered with a glutinous substance, and being thence conveyed into the mouth. (Compare woodpecker.) The Spaniards take advantage of this dexterity of the animal in the capture of insects by employing it (as well as the gecko) in their houses as a living fly-trap.

ORDER III.: SNAKES (OPHIDIA).

Body vermiform, covered with scales or scutes. Limbs and pectoral and pelvic arches absent. Bones of the face generally very movable. Teeth not lodged in sockets. Eyelids absent.

1. Non-Venomous Snakes.

The Ringed Snake (*Tropidonotus natrix*).

(Length up to nearly 5 feet.)

A. Locomotion and Locomotor Organs.

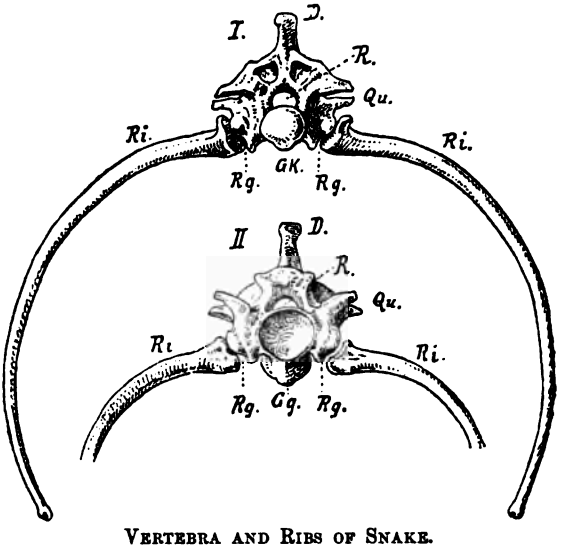
1. The ringed snake, like all other members of the order, is *limbless*, and accordingly (see lizard, Section E, 2 *a*) its body is elongated and *vermiform*. It progresses by a lateral sinuous or undulatory movement of the whole body, a method which has been described in the case of the lizard. Its progress in the water is effected in a similar manner.

For this kind of motion an extremely flexible body, or what amounts to the same thing, an *extremely flexible vertebral column*, is required. (Compare with other classes of Vertebrata.) This flexibility is attained by the presence of a *very large number of vertebræ*, which, moreover, are movably *articulated* to each other. The anterior face of the centrum of each vertebra is concave, and receives the spherical posterior surface of the centrum of the preceding vertebra, which moves freely in the concavity, as the humerus of mammals moves in the shoulder-joint (ball-and-socket joint).

2. The absence of limbs is compensated by the presence of a large number of ribs, on the free blunt ends of which the snake—in the absence of a *sternum*—glides along as upon so many legs. For this purpose the ribs are united by *ball-and-socket joints* (see Section 1), with the vertebræ, and moved in a backward and forward direction by means of numerous muscles arising from the body walls. At each undulation of the body the ribs are drawn forward and again forced backwards like

Digitized by Google

feet, while at the same time the *abdominal scutes*, which are connected with the ribs by muscles, are erected and wedged against inequalities of the surface, whereby any sliding backward is prevented. In ascending a tree, as it occasionally does, the ringed snake winds itself round the stem, and progresses upwards in the above-described manner. (Why do snakes progress with difficulty along a smooth surface?)



VERTEBRA AND RIBS OF SNAKE.
I., Posterior view; II., anterior view; Gk., centrum; Gg., concave face of centrum; R., spinal canal; Ri., ribs; D., neural spine; Qu., articular processes (zygosphene and zygantrum); Rg., transverse processes.

3. Not merely the limbs, but the *pectoral* and *pelvic* girdles also are wanting (slight rudiments of the latter are, however, to be found in some snakes). The *vertebral column*, accordingly, is almost *uniform* throughout its entire length.

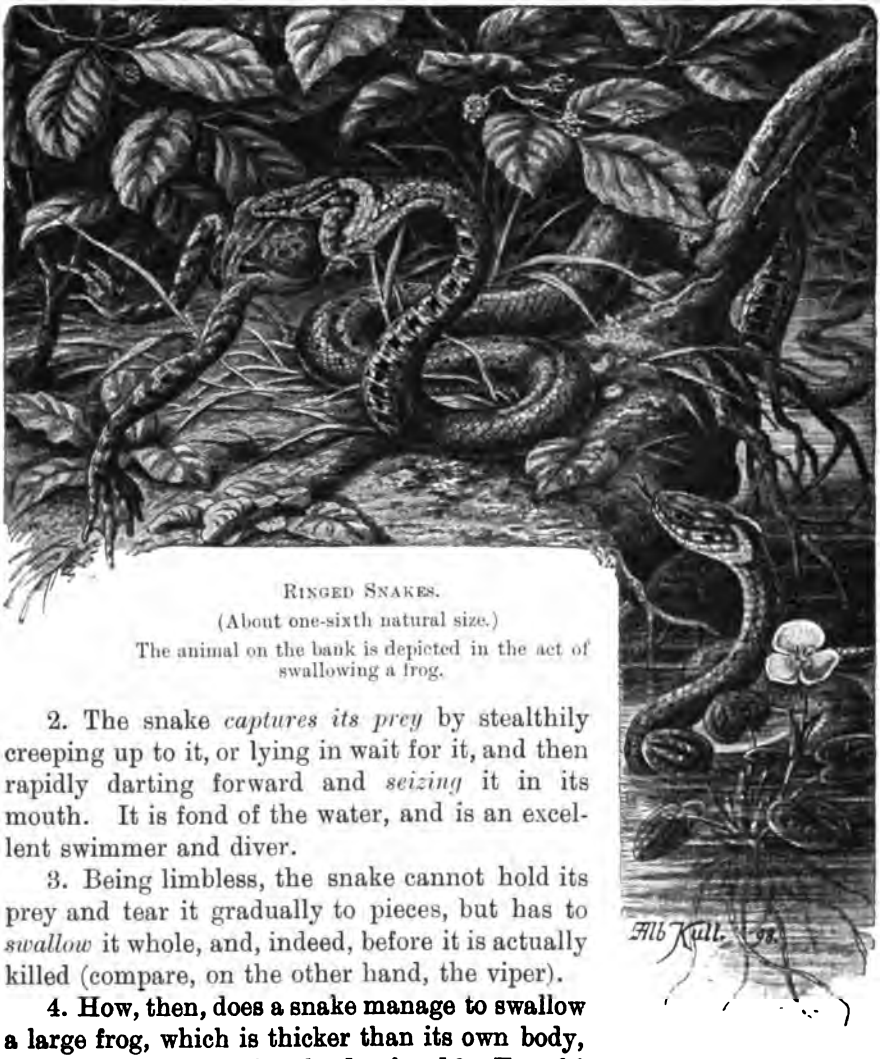
B. Food and the Manner in which it is obtained.

Like all other snakes, the ringed snake is pre-eminently a predaceous animal. Inasmuch as in its movements the animal's body, along its whole length, is in contact with the ground, a great deal of friction has to be overcome. Consequently, the movements of the animal entail a great expenditure of force. For this reason the snake spends the greater part of its time in *repose*, and may be described as a relatively *slow* and *awkward* animal. Hence, small animals (such as insects, snails, worms, etc.) are not sufficient to supply its wants (why not?), but it is obliged to have recourse to animals of larger size, viz., vertebrates. Its food, in fact, consists of amphibians and their larvæ, as well as fish. It is especially fond of frogs.

1. The ringed snake perceives its prey from a distance by sight. In place of an eyelid, the eye of the snake is covered by a transparent membrane, as the dial of a watch is covered by the glass. Its most developed sense is that of touch. It has its seat in the *tongue*, which is

Digitized by Google

deeply cleft and protrusible to a considerable distance; at its base it is enclosed within a sheath. It can be protruded even when the mouth is closed, through a notch at the tip of the snout. There is no trace of external *ears*, and the hearing is dull.



RINGED SNAKES.
(About one-sixth natural size.)
The animal on the bank is depicted in the act of swallowing a frog.

2. The snake *captures its prey* by stealthily creeping up to it, or lying in wait for it, and then rapidly darting forward and *seizing* it in its mouth. It is fond of the water, and is an excellent swimmer and diver.

3. Being limbless, the snake cannot hold its prey and tear it gradually to pieces, but has to *swallow* it whole, and, indeed, before it is actually killed (compare, on the other hand, the viper).

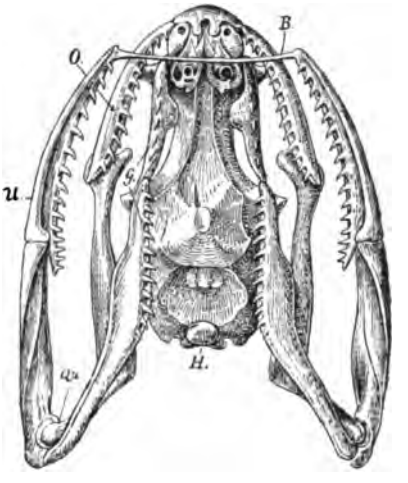
4. How, then, does a snake manage to swallow a large frog, which is thicker than its own body, and especially than its slender head? For this operation provision is made as follows:

(*a*) *The gape of the mouth is very wide* (give the situation of the angles of the mouth).

Digitized by Google

(*b*) *The upper and lower jaws are composed of movable bones*, united by fibrous ligaments, and in the act of swallowing these bones are widely separated from each other. In swallowing the head of the snake "appears pulled out of shape, and each single bone of the framework of the jaws put out of joint."

(*c*) *How the Prey is swallowed.*—After seizing a frog the snake inserts its numerous teeth (on jaws and palate, and not lodged in sockets) into its victim. All these teeth form so many hooks directed backwards, from which escape is impossible. Next, the framework of the jaws is elevated somewhat on one side, and moved some distance forwards. The same movement is next performed by the other side. In this manner the prey is drawn slowly but surely down the throat. In fact, the snake drags its jaws by a sort of climbing motion over its victim.



SKULL OF RINGED SNAKE, FROM BELOW.
O., Maxilla; U., mandible (the two rami of the latter, which are drawn apart in swallowing, are united by the tendinous ligament B.); G., teeth of the palate; Qu., quadrate bone; H., occipital condyle.

(*d*) An abundant secretion of *saliva* renders the prey *smooth and slippery* (importance of this).

(*e*) The *ribs* are not united on the ventral side (sternum absent); they can thus be bent apart, thereby allowing the gigantic morsel to pass down the gullet, which is itself dilatable.

(*f*) It might be supposed that during the process of deglutition the snake would be *suffocated*. This is prevented by the extension of the *trachea* along the floor of the mouth, almost as far as the chin, so that the animal is enabled to breathe while swallowing. The *lung*, moreover (a single right lung only is present), consists of a long membranous sac, which extends along the whole length of the body, and contains in its posterior portion a sufficient store of respiratory air.

5. Fleshy food being capable of digestion without previous mastication, the snake is *capable* of taking its nutriment in *huge morsels*. (Compare, on the other hand, the ox; see Part I., p. 102, Section 2.) The food is gradually dissolved by the *strongly acid juices secreted in the stomach*.

6. From the manner in which the snake feeds, we can understand why these animals only *take food at comparatively long intervals*, and are able to endure long fasts.

Digitized by Google

C. Habitat and Distribution.

On account of its food the ringed snake frequents localities abounding in frogs and fish. It is to be found throughout the whole of Europe except the Far North (why not there?), on the banks of brooks and rivers, and in marshes, swamps, and damp woods.

D. The Colour of its Scaly Coat

corresponds to the nature of its habitat. In swampy localities it is of an almost uniform black; in woody districts, on the other hand, brownish, like dry foliage. In other places it assumes a grey, bluish, or greenish tint. Several rows of black spots render the animal still more inconspicuous. This perfectly harmless species is easily distinguishable from all other native species by two white or yellow crescent-shaped spots at the back of the head. The scales of the back show in the centre a small elevation, or keel. The animal casts its skin several times during the year, pulling it off in one piece over its body while winding about among herbage, etc., just as one turns the finger of a glove inside out. The resemblance of the colour of the skin of this animal to that of the ground serves to hide its presence from its prey, and also affords an important means of protection from its numerous *enemies*, among which we must class foxes, martens, hedgehogs, pigs, storks, buzzards, etc.

E. Reproduction and Hibernation.

The female in summer lays in loose earth, among damp moss, etc., a large number (up to 36) of white-shelled eggs, about the size of pigeons' eggs. In Germany they are popularly known as "cock's eggs." It passes its hibernating sleep in all sorts of recesses to which frost cannot penetrate.

Other Non-Venomous Snakes.

The **Smooth Snake** (*Coronella austriaca*), a species closely allied to the ringed snake, is common in the mountainous districts of Germany, and is occasionally found in the South of England. It only attains to a length of about 25 inches. Its colour is usually brown, like the dry herbage of the soil (what is the importance of this?). From the viper it is easily distinguished by a dark spot on the back of the neck, and two rows of similarly coloured spots which extend along the back. It gets its name "smooth" snake from the fact that its scales are perfectly smooth, not keeled like those of the ringed snake. Its food consists principally of lizards (*L. vivipara*) and blind worms. For these

Digitized by Google

the snake lies in wait in the dense underwood, and should one of them approach too close, it darts with lightning speed upon its victim, seizes it in its jaws, and entwines it in two or three coils of its pliant body, after which it seizes the prey by the head and slowly forces it down its throat.

Of the gigantic snakes (**Pythons** and **Boas**) of the tropical zones the following species are frequently kept in zoological gardens and menageries:

The **Boa-Constrictor** is a native of the eastern and northern parts of South America. It is magnificently coloured, corresponding in this respect with the variegated vegetation of its habitat (compare with parrots, humming-birds, etc.). The ground colour is reddish-grey, with broad darker longitudinal stripes and spots of lighter colour. A full-grown snake, which reaches a length of more than 20 feet, is said to be able to kill and devour animals of the size of deer (enfolding them in the coils of its pliant body). Its food, however, consists principally of birds and small mammals. It was formerly worshipped by the natives as a deity.

Of equally gigantic size and rich colouring is the **Anaconda** (*Eunectes murinus*), also a native of South America. It lives by preference in and near the water. In places where ponds, streams, or lakes dry up completely during the hot season this snake buries itself in the mud and enters upon a summer sleep.

The **Python** (*Python molurus*) inhabits marshy districts in the East Indies. The colours of its scaly coat resemble those of the tiger's skin (light brown with irregular, dark four-cornered spots; compare with leopard). It attains to a length of above 20 feet. This and the two preceding species are very dangerous to man.

2. Venomous Snakes.

The Viper (*Pelias berus*).

(Length: female up to 26 inches, male up to 32 inches.)

This is our only native poisonous snake, and should therefore be known to everyone.

A. Distinguishing Characters.

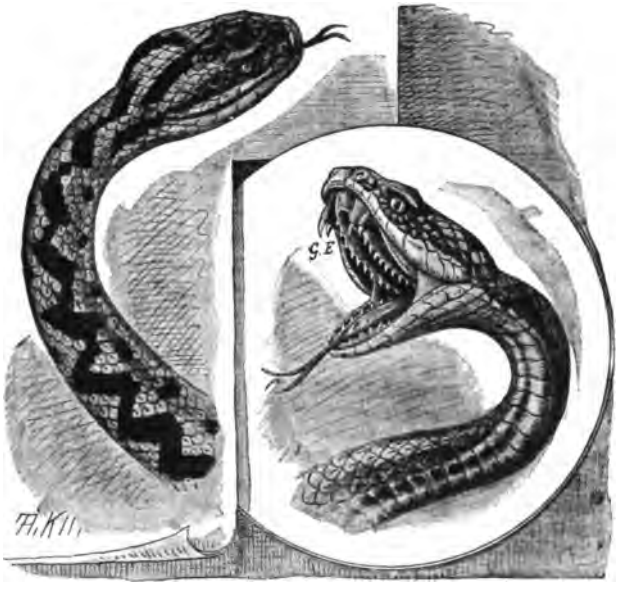
The viper may be distinguished from all other native snakes by the following characters: The flat triangular head, which is distinctly marked off from the neck; the thick, stout body; the short tail; and the presence of scales upon the head as well as scutes. The scales of the back, which are "carinated," *i.e.*, have a small prominence or crest in the middle, serve to distinguish it unmistakably from the smooth snake,

Digitized by Google

to which it bears a strong general resemblance (see above). The viper is, however, most easily recognised by the peculiar marking ("the sign of Cain"), viz., the dark zigzag band which runs from the neck down the back to the tail, and also by the dark H- or X-shaped mark on the head. The ground colour of the back is very variable: grey, greenish, brown, reddish-brown, in boggy places even black, but always corresponding very markedly to the colour of the soil of its habitat. (What is the importance of this correspondence of colours?)

B. Habitat.

The viper is met with everywhere: on mountains and plains, in meadows or fields, on marshes and heaths, and in woods. It resides in holes in the ground, or similar recesses, in which it also spends the winter (why is it obliged to hibernate?). During the daytime it lies hidden in its retreat, or basks idly in the warm sunshine (why?).



HEAD AND ANTERIOR PORTION OF THE BODY OF THE VIPER.
G., Poison fang; E., reserve fang.

C. Pursuit of Prey.

This is not commenced until nightfall. The viper feeds principally on mice, which it pursues into their holes (its shape is adapted for this). The young (which are brought forth alive) live on small lizards.

(*a*) The pupil of the eye is vertical and very dilatable, characters indicative of a nocturnal habit (compare with cat).

(*b*) The maxillary bones are very short, in fact rudimentary, and in addition to the poison fangs, which are as brittle as glass, carry no other hook-teeth (see ringed snake). The viper, therefore, would be unable to *retain a hold* on its struggling prey. Accordingly, it kills the latter

Digitized by Google

by *poisoning* it before swallowing it. The poison fangs are extremely sharp and somewhat curved, and when the mouth is closed, or while the prey is being swallowed, lie within folds of the mucous membrane of the mouth (why?), but are erected when the viper wishes to bite. They are traversed by a fine canal connected at the root of the tooth with a gland in which the deadly poison is secreted. Close to the extremity of the fang, on its anterior surface, the canal opens in a fine slit, through which the poison is injected into the wound of the prey. Behind the poison fang are situated reserve fangs destined to take the place of the functional fang should the latter be broken off or lost (why is this necessary?). A small drop of the venom is sufficient to instantly kill a small vertebrate, and since the viper lives chiefly upon mice, it would be one of our most useful animals were it not that its bite is dangerous, and sometimes even fatal, to ourselves.

D. The Viper in its Relations to Man.

The action of the poison varies according to the quantity which has been injected into the wound. The bite may produce violent illness, or a lingering malady lasting for years, or even death. Even the head of the viper when cut off can still inflict a bite, and the poison remains active after being dried and then moistened again. One ought, therefore, never to walk with naked feet in a place frequented by these creatures, or sit down without having first carefully examined the spot. For the same reason the natural enemies of the viper, viz., the weasel, hedgehog, buzzard, etc., deserve careful protection, while, finally, the pestiferous creature should be actively pursued at night. High leather boots afford adequate protection against its bite.

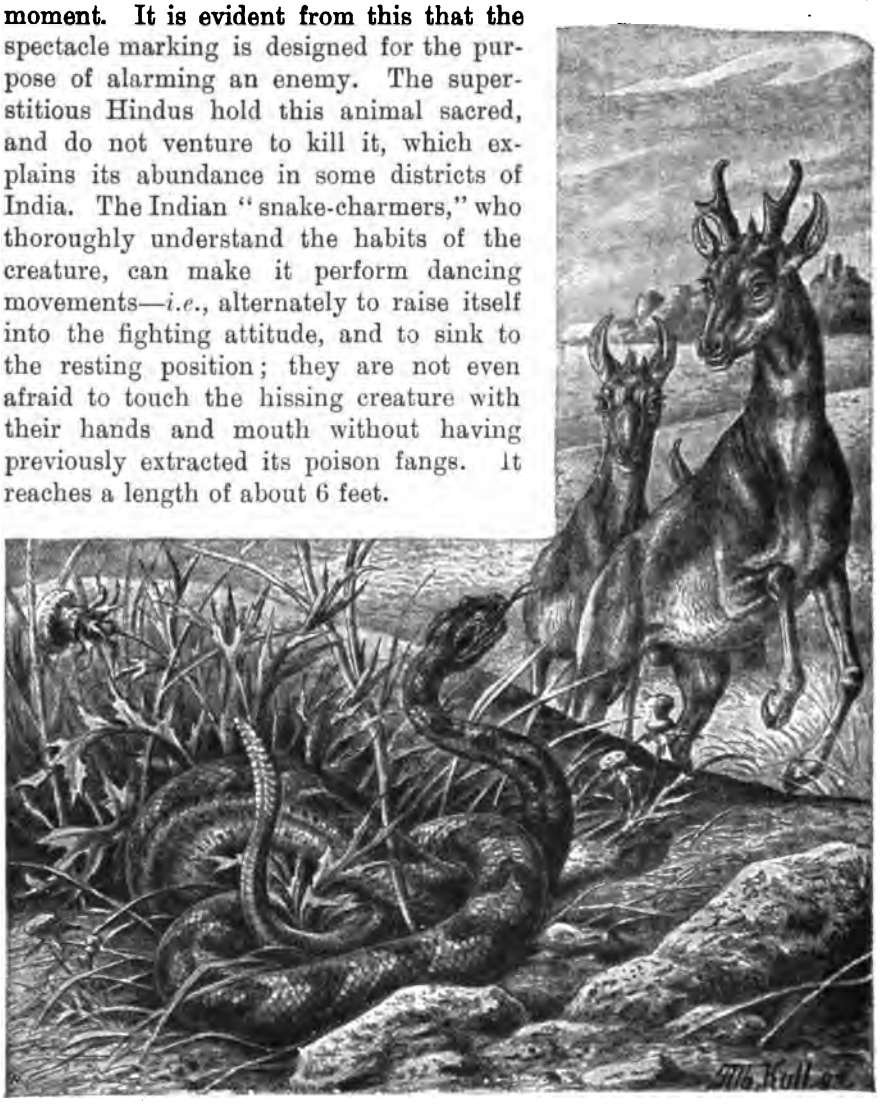
When a person is bitten by a viper, the wound should be cauterized as soon as possible, or the injured part cut out, after which the limb should be bound up tightly until medical aid arrives. The most efficient antidote is alcohol given in large quantities in the form of brandy, rum, wine, etc.

Other Poisonous Snakes.

The **Cobra di Capello**, or **Spectacled Snake** (*Naja tripudians*), is found in the whole of Southern Asia and the neighbouring islands. It derives the second name from the spectacle-shaped markings on the back of the neck. Protected by its yellowish-brown colour, this snake lazily pursues its prey, which consists of small vertebrates, in stone heaps, old walls, and similar places. When teased or alarmed, it assumes a menacing or defiant attitude (like many caterpillars), raising the anterior part of its

Digitized by Google

body, and by extension of the anterior ribs dilating its neck into a disc or hood, so that the spectacular marking is drawn widely apart, the head being at the same time held horizontally, and ready to strike at any moment. It is evident from this that the spectacle marking is designed for the purpose of alarming an enemy. The superstitious Hindus hold this animal sacred, and do not venture to kill it, which explains its abundance in some districts of India. The Indian "snake-charmers," who thoroughly understand the habits of the creature, can make it perform dancing movements—*i.e.*, alternately to raise itself into the fighting attitude, and to sink to the resting position; they are not even afraid to touch the hissing creature with their hands and mouth without having previously extracted its poison fangs. It reaches a length of about 6 feet.



RATTLESNAKE ALARMED BY PRONG-BUCK. (About one-sixth natural size.)

The most notorious of the poisonous snakes of North America is the **Rattlesnake** (*Crotalus durissus*). Its scaly coat is of a greyish-brown

Digitized by Google

colour with dark spots, scarcely distinguishable from the rocky soil on which it lives. Its length is about 5 feet, and at the extremity of its body it is provided with a peculiar structure, "the rattle" (hence its name), which consists of a series of hollow horny rings; these are portions of the epidermis left after the successive castings of the skin. When the animal shakes its tail, these horny rings, rubbing against each other, produce a rattling noise. The snake, however, never shakes its rattle while creeping slowly along or when in quest of prey (consisting of small vertebrates), but only when it believes itself in danger, which shows that the rattle is really a means of inspiring fear in its enemies.

ORDER III.: CROCODILES (CROCODILIA).

Body of lacertilian shape, with long, laterally-compressed tail; bony dermal scutes developed on the back; four legs; teeth lodged in sockets.

The Common Crocodile (*Crocodilus niloticus*).

(Length up to 20 feet.)

The crocodile has the shape of a gigantic lizard, and, like all the members of this order, is an *inhabitant of the water.* It is found in the rivers and lakes, both large and small, of nearly the whole of Africa and some of the neighbouring islands. In the lower course of the Nile, however (from which river it derives its specific name), it has almost disappeared, as a result of the traffic of rapid steamers of deep draught and of incessant persecution, for the bullets of modern firearms are able to penetrate its powerful *armour,* which consists of horny scutes, supported, especially on the back, by large bony plates developed in the subjacent dermal layer. The scutes of the back are carinated (see viper); those of the tail carry in its fore-part double, towards the end single, toothed ridges. The colour of the monster is a dark bronze green. During the daytime it lies asleep in the sun on a sand-bank or muddy shore, having all the appearance of some weathered old tree-trunk. At nightfall it rouses itself for the *pursuit of its prey.* The vertical, very dilatable *pupil* indicates its nocturnal habits. (Compare with cat.) Its laterally-compressed, powerful, and very movable tail, which acts as a *propeller* (see tadpole of frog and newt), and the *webbed* toes of the hind feet render it an adept and rapid swimmer. It cleaves the waters as easily as an arrow does the air. The *auditory passages* can be closed by two folds of skin, and the *nostrils* by the pressing together of their swollen edges, arrangements which enable the animal to remain below the water for a prolonged period. (Compare in this respect aquatic

Digitized by Google

species among mammals and birds.) The powerful jaws are furnished with large conical teeth. These teeth are firmly lodged in sockets (see p. 230), and, as in carnivorous mammals, some bite between each other, some outside others. The jaws form, in fact, two powerful toothed shear-blades; and by shutting them with a snap the monster can easily tear off a leg or the head of any of the larger mammals which come to the shore to drink (antelopes, goats, sheep, horses), or tear a man to pieces. Its *food*, however, consists principally of small aquatic animals, especially fish. Though a bold creature in its natural element, the water, the crocodile is cowardly on the land, where, however, it also moves fairly rapidly by the aid of its powerful *legs*. In the hot season, if the waters of its habitat dry up, the animal buries itself in the mud, and indulges in a *summer sleep*. The female lays annually about two hundred hard-shelled eggs, of the size of goose eggs, and buries them in the sand or mud. The flesh, fat, and eggs of the crocodile are considered a delicacy by the natives. From the contents of four musk-glands, two near the anus and one behind each cheek, the inhabitants of the Soudan prepare a salve or ointment, used by the women for rubbing on the hair and body as a perfume.

Allied Species.

The **Garial** (*Garialis gangetius*) is found in the Ganges, Indus and Brahmaputra. It is distinguished by its elongated, beak-like snout, and reaches a length of more than 17 feet.

The **Alligator**, or **Caiman** (*Alligator mississippiensis*), is abundant in the southern parts of North America. Its head bears a strong resemblance to that of the pike, and it attains to a length of about 15 feet. The female lays its eggs in bushes and reed-banks, and covers them with reeds, leaves, etc. The eggs are hatched by the warmth which is generated by the decay of this vegetable matter. The animal, as a rule, is not dangerous to man.

ORDER IV.: TORTOISES (CHELONIA).

Body broad, enclosed in a shell composed of a dorsal and ventral shield. The jaws are toothless and covered with horny sheaths. Two pairs of limbs present.

Digitized by Google

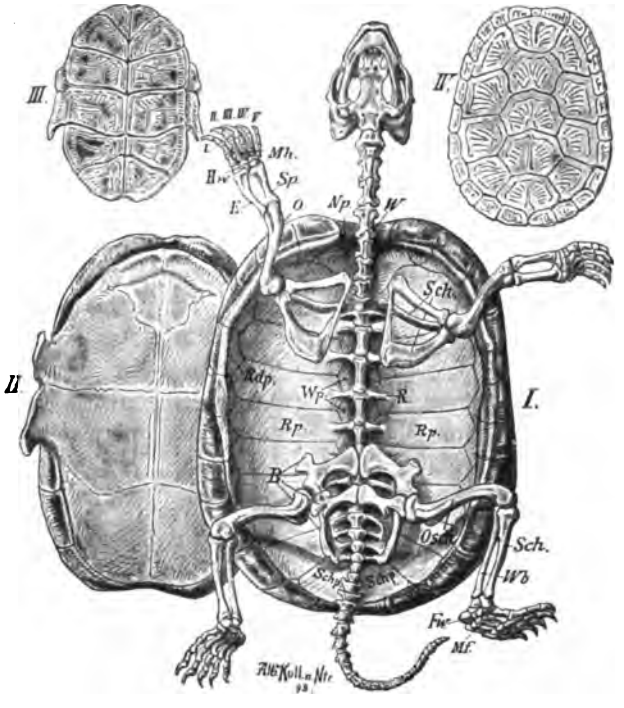
Family 1: Pond, Marsh, and River Tortoises (Emydæ).

The European Pond or Marsh Tortoise (*Emys europæa*).

(Total length up to 12 inches.)

A. Body Armour.

The body is toadlike, and enclosed in a shield or body armour consisting of two portions, covering respectively the back and abdomen, and known as the *carapace* and the *plastron*.



W., vertebral column.
Sch., bones of the shoulder girdle.
O., humerus.
E., ulna.
Sp., radius.
Hw., carpal bones.
Mh., metacarpal bones.
B., pelvis.
Osch., femur.
Schb., tibia.
Wb., fibula.
Fw., tarsal bones.
Mf., metatarsals.
Wp., neural plates.
R., ribs.
Rp., costal plates.
Rdp., marginal plate.
Np., nuchal plate.
Schp., pygal plates.

SKELETON AND BODY ARMOUR OF POND TORTOISE.

I., Skeleton and dorsal shield (carapace) from below.
II., ventral shield (plastron), composed of dermal bones from above (internally).
III., plastron from below (outwardly).
IV., carapace from above (outwardly).
III. and IV. with the horny epidermic plates covering the bony plates.

1. When viewed from their inner side, both shields are found to consist of *bony plates*, which are rigidly united with each other by serrated sutures (see Part I., p. 11, Section *a*).

The small plates which form the central row of the *dorsal carapace* are intimately anchylosed with the vertebral column, being, in fact,

Digitized by Google

formed by the expansion of the dorsal spines of the vertebræ (see Part I., p. 4). They are accordingly termed *neural plates*. To their right and left lies a row of larger plates, which are formed by the expansion of the ribs, and are hence called *costal plates*. They are surrounded by a series of smaller *marginal plates*, which are formed by ossification of the lower skin, or derma. (Where have we previously met with dermal ossifications?) Both the *nuchal* and the two *pygal plates*, which lie respectively in front and behind the *neural plates*, are dermal ossifications, as are also the plates composing the ventral shield or plastron.

2. Above this bony armour lie a series of smaller and larger detachable *horny plates*, constituting the so-called tortoiseshell. They lie adjacent to each other, like the slabs of a pavement, and are developed from the upper skin, or epidermis. These plates do *not coincide* with the subjacent bony plates, but are so arranged as to cover the sutures of the latter. These epidermal structures are not cast periodically, like those of lizards and snakes, but fragments are detached from the surface, and are renewed by growth from within outwards.

3. The two portions, dorsal and ventral, of the bony armour are firmly united laterally. In front and behind openings are left of sufficient width *to allow the head and limbs to be withdrawn into the shell*. In the case of the head this retraction is rendered possible owing to the fact that the vertebræ of the long neck are movably articulated, and can be folded back on each other in the form of an S. In retracting the limbs, the humerus and femur are drawn forwards, and the lower arm and leg laid up close against them. The tail is laid on one side, against one of the hind-legs. The armour of the tortoise furnishes it with an excellent means of protection against—

B. Its Enemies.

Nevertheless, cats and falcons manage to get their claws through the openings, and to pull out the fleshy parts. An additional protection to the animal is—

C. Its Colour.

This completely resembles that of the muddy banks where, in a safe hiding-place, the animal sleeps and suns itself during the day. The horny plates of the carapace, as well as the skin of the neck and head and the horny scales on the legs and tail, are of a blackish-green colour, dotted and streaked with yellow. The plates of the plastron vary in colour from yellow to blackish-brown.

Digitized by Google

D. Senses.

At the least noise the animal withdraws the unprotected parts of its body into its shell, or, if it has its head above the surface of the water, immediately disappears; this indicates a sharp sense of *hearing*. The tympanic membrane is exposed. The *eyes* are furnished with two lids and a nictitating membrane.

E. Food.

The tortoise obtains its food in the water, and mostly at night-time. It consists of worms, insects, frogs, newts and their larvæ, and especially fish.

1. Hence it has its habitat in standing or slowly-running waters (whence name pond tortoise). Its home is in Southern and Eastern Europe. In Germany it is found in the basin of the Oder and Vistula, as well as in the Havel and Spree.

2. On *land* the tortoise progresses slowly and lazily on its *short legs*, the whole of the soles of the feet being in contact with the ground. Its heavy armour renders the *body immovable*, and hence incapable of assisting in the animal's progress. (Compare, on the other hand, the other reptilian orders. Notice how the tortoise turns over when it is placed on its back.) In the *water*, however, the animal is very nimble. (Why is this necessary?) Its *flat body*, which recalls the form of a water-beetle (contrast with land tortoises) cuts with ease through the water, and its short legs, the *toes of which are freely movable and united by webs*, form excellent oars (compare with other aquatic animals).

3. Teeth are absent, their place being supplied by *sharp-edged, horny sheaths covering the jaws* (compare with birds). By means of these, the edges of the upper jaw overlapping those of the lower, the toothless mouth can bite pieces out of its prey. Prey of large size (frogs, fish) is held, while being consumed, by the *strong nails* of the toes. While a tortoise is consuming a fish, the swimming-bladder of the latter frequently rises to the surface of the water; hence floating swimming-bladders are always a sign of the presence of tortoises.

F. Respiration.

On account of the solid armour, breathing cannot be effected by expansion and contraction of the chest. The animal, in fact, breathes by closing its mouth and nostrils, and then forcing into the lungs—or, as it were, swallowing—the air which has previously entered by the oral and nasal apertures. (These swallowing movements may be distinctly observed by watching the animal.) The *nostrils* are two dot-like aper-

Digitized by Google

tures situated on the tip of the snout, so that in breathing the animal need only raise the latter above the surface of the water (compare with whale). The respiratory needs of the animal are very small, so that it can remain a considerable time below the surface. During its *hibernation* the respiration almost ceases altogether.

G. Reproduction.

The female in the spring lays from about ten to fifteen hard-shelled eggs in a pit which it scratches with its hind-feet in the sand or mud. When the eggs have been deposited, the pit is filled up again, and the animal stamps down the earth, in order to hide all traces of it, by alternately lifting and letting fall upon it the hinder part of its body.

H. Importance to Man.

The flesh of the tortoise is eatable. Its depredations among fish, however, far outbalance its uses.

Other Species.

Family 2.

The **Land Tortoises** (*Chersidæ*) live chiefly on the juicy parts of plants, and hence inhabit by preference woods and bushy places. Their toes are united up to the nails (padlike feet; see elephant), the animals walking, in a slow and lazy fashion, upon callous soles. The dorsal shield is strongly convex, and consequently capable of withstanding violent blows.

The most familiar species is the **Greek Land Tortoise** (*Testudo græca*), which inhabits Southern Europe, and attains to a weight of about 5½ pounds. The carapace is spotted yellow and black. The flesh is eatable.

The **Giant Tortoises** (*T. indica*) of the Galapagos Islands are enormous animals, reaching a length of nearly 4 feet, and weighing as much as 450 pounds. Owing to the foolish and incessant persecution to which these animals have been subjected for decades, they are now almost extinct.

Family 3.

The **Turtles** (*Chelonidæ*) are true aquatic animals, which only go ashore for the purpose of depositing their eggs. They are excellent swimmers and divers, with a depressed and flattened body (why?), and fin-like feet (see seal).

Digitized by Google

The **Edible** or **Green Turtle** (*Chelone viridis*) inhabits all the seas of the tropical and temperate zones, and attains to a weight of nearly 1,000 pounds. It is everywhere actively pursued on account of its eggs and excellent flesh (turtle soup).

The **Hawk-Bill Turtle** (*C. imbricata*) is subjected to even keener persecution, as the horny plates of its carapace furnish the best tortoise-

HAWK-BILL TURTLES IN PURSUIT OF FISH.
(The larger animal about one-twelfth natural size.)

shell. These plates overlap each other like roof-tiles, and are of a brown ground colour variegated with yellow. In boiling water they can be welded into any shape, which they retain after cooling. The employment of tortoiseshell for combs and other ornamental objects is well known. The animal attains to a length of over 3 feet, and inhabits principally the seas between the two tropics.

Digitized by Google

CLASS IV.: AMPHIBIANS (AMPHIBIA).

VERTEBRATE animals of varying body temperature (cold-blooded), with naked skin, breathing by gills in the earlier stages of their life, later by lungs as well as gills, or lungs only; mostly oviparous; limbs in form of legs (in a few amphibians not noticed here the posterior pair or both pairs of limbs are absent).

1. **Form of Body and Limbs.**—In regard to the shape of their body, the amphibia may be divided into two distinct groups, in one of which, the frog-like amphibians (*Batrachia* or *Anoura*), the body is broad, flat, and tailless, and the limbs well developed, and adapted for leaping, walking, and climbing; in the other group, tailed amphibians (*Saurobatrachia* or *Urodela*), the limbs are small and feeble, and the body accordingly much elongated, lizard-like, or almost vermiform, and provided with a long tail. Among the terrestrial species of the latter group (*e.g.*, spotted salamander), the tail is rounded (supporting tail); in those which are principally or exclusively confined to an aquatic life, it is laterally compressed (swimming-tail).

2. The **Skeleton** corresponds to these two chief types of body shape. In the Batrachia, the vertebral column consists of only a small number of vertebræ. Its terminal segment (see Fig., p. 255) as well as the pelvic girdle form a strong and firm support for the hind-limbs, which are specially concerned in locomotion. In the Urodela, on the other hand, there is a large number of vertebræ freely movable on one another, and the pelvic girdle is weak. The limbs, and the pectoral and pelvic girdles, consist of bony elements corresponding to those of the higher Vertebrata (see Part I., p. 2).

3. **Integument.**—(*a*) Amphibians, like reptiles, are animals of varying body temperature (see p. 229), and are therefore without any special provisions for the preservation of heat. Hence, in the temperate zone, these animals only lead an active life during the warm season; with the approach of the colder period of the year, their vital activities (respiration, circulation) grow slacker and slacker, until finally the animals relapse into the sleep of *hibernation*. On this account, too, many species

Digitized by Google

prefer the upper and warmer strata of the water, or are fond of enjoying the enlivening rays of the sun. (Frogs, newts. Why does the number of amphibious species increase as we approach the equator? and why are none to be found in the frigid zone?)

(*b*) The skin in amphibia is perfectly naked, and is only slightly protected against excessive evaporation by the slimy mucus secreted from numerous glands opening on its surface. Hence, dry heat soon proves injurious to these animals. If a frog or newt, for instance, is confined in a dry space, it will dry up and die in a short time, often even after half a day; if, on the other hand, such an animal, nearly parched up, is wrapped in a damp cloth, leaving only the head exposed, it will rapidly increase in weight, showing that the skin also takes up water. No amphibian takes in water by drinking. This explains why many amphibians lead *an aquatic existence*, or at most keep within an easy distance from the water (*e.g.*, the edible frog); while those which are terrestrial are exclusively *nocturnal* in their habits (on account of the dew, moist night air), and only in exceptional cases, in wet weather, leave their damp hiding-places during the day (*e.g.*, toad and spotted salamander. (Why cannot amphibians live in deserts? and why do many which inhabit the torrid zone pass the summer in sleep?)

(*c*) In addition to the above-mentioned mucus, the skin of amphibians secretes regularly from special glands an acid juice of unpleasant taste, or *poisonous*, which more (spotted salamander) or less (tree-frog) effectually protects the animals from the pursuit of enemies.

(*d*) The *colour* of the skin is a further and very important means of protection (protective or warning coloration—examples). Many amphibians are even capable of changing their colour in such a manner as to make it correspond with their surroundings. How is this effected? In the skin are "cells" (*i.e.*, minute protoplasmic elements, of which the bodies of all animals and plants are composed) filled with brown, black, yellow, red, and other coloured pigments. These coloured particles are sometimes closely packed together in the centre of the cells; at other times they are spread apart over the whole cell, and the colour of the animal varies according as the one or the other of these arrangements obtains in the cell. Thus, if the brown pigment is spread out over the cell (as in the tree-frog when it sits on the brown bark of a tree or a dark-coloured leaf), the whole skin assumes a brown colour, etc. In considering the question as to whether the animal is able to change its colour *voluntarily*, we may be guided by what happens in ourselves. Thus, if we see anything which rouses our sense of shame or our anger, our face blushes with shame or rage, or, on the other hand, it may grow pale from the sight of anything which instils fear or alarm. In both

Digitized by Google

cases the change takes place involuntarily, and even contrary to our wish. A blind man standing by our side, but incapable of perceiving any of these sights, neither blushes nor turns pale. Exactly the same happens in animals which are capable of changing their colour. They can only do this while they see, but not if they are deprived of sight. Hence the change of colour is effected through the *stimulation* of the *eye* (and that in such a manner that the stimulus acting on the optic nerve is transmitted or reflected to the nerve fibres which are connected with the pigment cells).

(*e*) The outermost layers of the skin are periodically *cast* either as a whole or in patches.

4. **Respiration.**—In the *larval* stages (see Section 6) respiration is always effected by gills or branchiæ (see fish), in the fully-developed animal usually by *lungs*. In a few only (see Proteus) branchiæ co-exist with lungs throughout life. Ribs being entirely absent (Batrachia), or short rudiments of them only present (Urodela), dilatation of the chest becomes impossible. The respiratory air is consequently swallowed. (Observe the under side of the head in the frog. · See also tortoise, p. 249.) Nevertheless, many amphibians breathing exclusively by lungs can remain a considerable time below the water, and even hibernate for months in the mud of ponds, etc. In these animals, in fact, contrary to what obtains in most other animals breathing by lungs, an exchange between carbonic acid gas and oxygen is effected through the agency of the moist and naked skin (cutaneous respiration; compare also with the gills of fishes).

5. The **Heart** consists of two auricles and one ventricle (see Reptiles, p. 229).

6. **Reproduction.**—Most amphibians are oviparous. The eggs being usually laid in the water (larvæ breathe by gills), they are destitute of firm envelopes like those of the eggs of land animals. A few only are viviparous. As a rule, the young as they escape from the egg have a form widely different from that of the parents, and are consequently described as *larvæ* (see Insects). It is only after a series of manifold changes (metamorphosis) that the larva develops into the perfect amphibian (see edible frog, newt, land salamander). As development usually takes place in the water, the life of the young amphibian resembles that of a fish. These animals, therefore, may truly be called amphibious, since at one stage of life they live actually in the water, in the other on land in air.

Digitized by Google

ORDER I.: FROGS AND TOADS (ANURA).

Body broad, the adult animal always tailless and provided with two pairs of well-developed limbs.

The Edible Frog (*Rana esculenta*).

(Length from 2½ to 3 inches.)

A. Distribution and Habitat.

This species is met with over the whole of Europe, North Africa, and Western Asia. It occurs in England only in Cambridgeshire and Norfolk, having been imported at some time or other from the Continent. It

Sch., Scapula.
O., humerus.
U., conjoined radius and ulna.
Hw., carpal bones.
M., metacarpal bones.
II.-V., digits of manus.
W., vertebræ.
St., urostyle.
D., ilium.
Osch., femur.
Usch., conjoined tibia and fibula.
Fw., calcaneo-astragalus portion of tarsus.
Mf., metatarsal bones.
I.-V., digits of the pes.

Skeleton of the Edible Frog (shown within the Outline of the Body).
(About three-quarters natural size.)

frequents principally pieces of water richly overgrown with plants, and the banks of which are abundantly covered with grass, rushes, and bushes.

B. Colour.

Amid such surroundings the animal's colour is its chief protection against its enemies, the stork, heron, pike, etc. The skin of its upper surface is grass green, variegated with dark spots and three yellow longitudinal stripes, an arrangement of colours which renders the animal quite invisible amid the dense growth of water-plants and the high grass of the banks, nor does its yellow or white under side render it conspicuous amid such surroundings (why not?).

Digitized by Google

C. Body Heat.

In regard to the *body heat*, the naked integument, and the mucus secreted by the latter, compare p. 252, Section 3, *a* and *b*.

D. Food.

The frog feeds principally on insects, spiders, and slugs, but also consumes small fish and smaller-sized amphibians, including those of its own species. In places it may do considerable damage to fish.

1. *Organs of Sense.*—The frog recognises its prey only by its movements; immovable objects do not arouse its attention. With its large protruding and retractile *eyes*, which are furnished with an upper lid and nictitating membrane, it constantly surveys its surroundings. The *hearing* appears to be very acute, since at the slightest suspicious noise the animal leaps into the water, where few of its enemies can pursue it. The tympanic membrane is visible in the form of a circular disc behind the eyes. The nostrils are closed while the animal is in the water by cutaneous flaps. (Why?)

2. *Movements.*—(*a*) On land the frog pursues its prey by leaping. By a sudden stretching of the bent hind-legs, which are much longer than the broad, disc-shaped body, it can propel itself to a considerable distance. (Notice the remarkable length of the upper tarsal bones—calcaneo-astragalus.) The *fore-limbs*, which are much shorter and weaker, serve to support the body in falling.

(*b*) In the water the frog progresses by *swimming* by the help of its hind-legs, the five toes of which are long and united by webs. (Man has copied the frog in the motion of his legs in swimming.) While swimming, the fore-legs of the frog are brought up close against the body, and, as they are not called into action, their toes are free and much shorter than the hind-toes. (Compare with crocodile.)

(*c*) As progressive movement is carried out almost entirely by the hind-legs, these limbs are extremely *muscular*. The posterior portions of the *skeleton*, which are strongly developed, afford these legs a firm support, and also furnish the requisite surfaces of attachment for the muscles. The terminal portion of the vertebral column has the form of a long, rod-shaped bone (formed by the coalescence of the coccygeal vertebræ), parallel to which are two, likewise rod-shaped, pelvic bones (the ilia). The hind-legs of the frog are in many countries considered a delicacy. Unfortunately, they are usually obtained in an abominably cruel manner, being cut off from the live animal, which is thrown back into the water, in the erroneous belief that the legs grow again. (In the

Digitized by Google

newts, on the other hand, lost parts of the body—tail, legs, eyes, etc.—grow again.)

3. *Mouth.*—(*a*) The *tongue*, which is very extensile and has two long, pointed lobes behind, is used as an organ of prehension. It is fixed by its *anterior* end to the floor of the mouth, from which it can be rapidly protruded (fly-flap).

(*b*) Small *curved teeth* are developed in the upper jaw and palate, but are only used for holding the food and pushing it on towards the throat (see lizard).

E. Reproduction.

1. About the beginning of May, with the revival of insect life, the frogs emerge from the mud in which they have passed about seven months of *hibernation*. (Why?) At this time the warm spring nights are rendered everywhere sonorous with their concerts. As among song-birds, it is the *male* only that is *vocally gifted*. The sound of the voice is strengthened by two *vocal sacs*, situated near the angles of the mouth, and protruded from slits in the act of croaking.

2. At the beginning of June the female *spawns*—*i.e.*, deposits its eggs. Their number is large (as many as 4,000), though not excessive when we consider the numerous enemies to which the frog and its young are exposed, and the fact that the parents neither concern themselves about the eggs or the young.

3. The *eggs*, which lie in lumps at the bottom of the water, are hatched by the heat of the sun transmitted through the water. They have the form of small yellowish balls, and are surrounded by a transparent, jelly-like envelope, which swells considerably in the water. (Why do they not require a solid envelope?) This jelly protects the eggs against injury, and also from being swallowed by fish and other aquatic animals. (Why? Only the duck can consume them by means of its broad, spoon-shaped bill.) The jelly further increases the space between the separate eggs (for purposes of respiration), and finally constitutes the earliest nutriment of the larvæ.

F. Development.

Observe this in an aquarium. As the larvæ, or tadpoles, pass through all the stages of their development in the water, they have in all respects the structure of an aquatic animal.

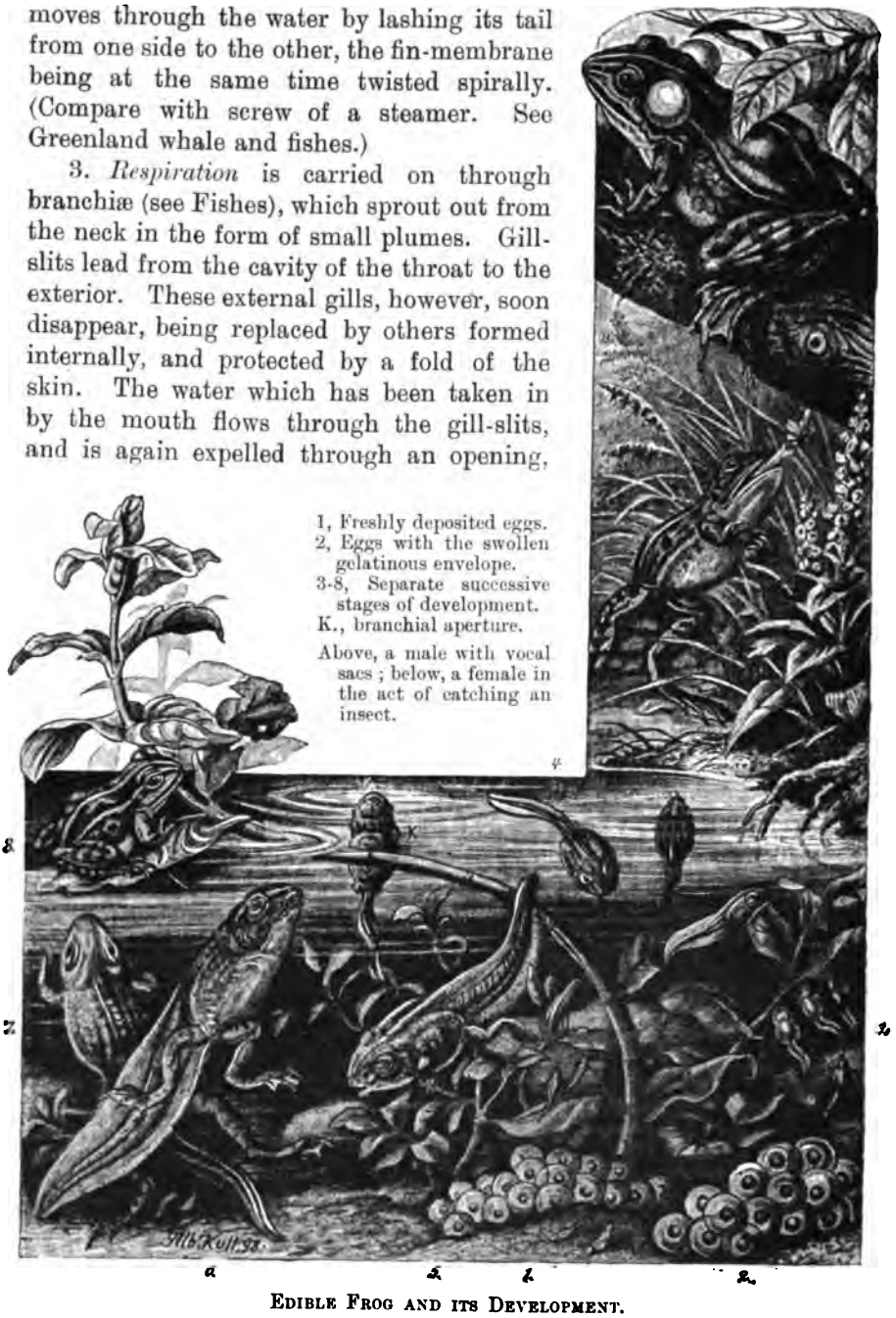
1. In *shape* they are like fish (which see); the head passes directly into the limbless trunk, which is continued into

2. A laterally-compressed swimming-tail, exceeding the length of the body, and completely surrounded by a broad fin-membrane. The larva

Digitized by Google

moves through the water by lashing its tail from one side to the other, the fin-membrane being at the same time twisted spirally. (Compare with screw of a steamer. See Greenland whale and fishes.)

3. *Respiration* is carried on through branchiæ (see Fishes), which sprout out from the neck in the form of small plumes. Gill-slits lead from the cavity of the throat to the exterior. These external gills, however, soon disappear, being replaced by others formed internally, and protected by a fold of the skin. The water which has been taken in by the mouth flows through the gill-slits, and is again expelled through an opening,



1, Freshly deposited eggs.
2, Eggs with the swollen gelatinous envelope.
3-8, Separate successive stages of development.
K., branchial aperture.
Above, a male with vocal sacs; below, a female in the act of catching an insect.

EDIBLE FROG AND ITS DEVELOPMENT.

Digitized by Google

or respiratory pore, on the left side of the throat (compare with fishes).

4. The *mouth* in this stage is a small opening, furnished with horny teeth and horny sheaths on the jaws. The food of the larva now consists chiefly of dead vegetable substances. With the scum of algæ, etc., which covers stones and the larger aquatic plants, the larvæ also take up a quantity of microscopic animals, and are also fond of nibbling at dead animals. The *intestine* is long and spirally coiled, enabling the animal to take in and to thoroughly use up a large quantity of these materials, which contain but little nutriment. (Compare the long intestine of ruminants.)

5. As the larva grows in size it undergoes a number of other changes. First the *hind-limbs* and subsequently the *fore-limbs* are budded forth, the skeleton becomes harder, and the swimming-tail gradually disappears. The creature thus gradually becomes adapted for motion on land.

The branchiæ disappear, lungs being developed in their place; thus the animal becomes an "air-breather." The head assumes more the frog-like shape, the mouth steadily increases in width, and the horny teeth and sheaths are lost. The intestine assumes the shape typical of carnivorous animals (see cat), the tongue is developed, and the animal now begins to feed on living prey. In short, the fishlike tadpole has become a frog.

Other Batrachians.

The commonest of our species of frogs is the **Common Frog** (*Rana temporaria*; see illustration, p. 238). This animal is easily recognisable by the dark spot in the region of the ear and the transversely striped hind-legs. It changes its colour in accordance with its habitat, being dusky grey or blackish-brown in woods where the soil is covered with leaves, or similar localities, whilst on rich grassy tracts it assumes a dress of lighter colours intermixed with green. It spawns as early as March, and the larvæ have reached their full development by June. Hence this species can inhabit localities where the summer is only of a few months' duration (Northern Europe, high mountains). The spawn soon rises from the bottom to the surface of the water, being thus exposed to the direct rays of the sun—an advantage during the raw season of the year—while the eggs are black, and thus absorb much more heat from the sun than the lighter-coloured eggs of its green-coated relative. (Dark clothes are warmer in summer than light clothes; why?) The young frogs often leave the water in great swarms (popular stories of showers of frogs), and disperse over gardens, meadows, fields, and woods. During the daytime the frog generally secludes itself

Digitized by Google

from the hot rays of the sun: for though passing its existence chiefly on land, it cannot live without moisture (see p. 253). At night, however, when the dew refreshes the earth, the frog emerges from its retreat and pursues its chase after all sorts of insects, slugs, and other small creatures. Its hind-legs are a favourite delicacy on the Continent.

The Toad (*Bufo vulgaris*).—This animal also visits the water only for the purpose of depositing its spawn (which forms necklace-like strings), and only leaves its retreats at the approach of night or during wet weather. Its dusky, brown or green colour, combined with the numerous wart-like processes which cover the whole of its body, give the animal a strong resemblance to a lump of earth. On the other hand, if the animal hides during the day among large leaves, the skin assumes a greenish colour, whilst if a clay soil is chosen for its habitat the colour changes correspondingly, varying from a brownish-yellow to a light yellow. The skin of the toad secretes a whitish mucus of unpleasant smell and slightly poisonous properties, which, however, can only become dangerous to man if it happens to come in contact with a mucous membrane (eye, mouth). (Protection against enemies; note the behaviour of a dog to whose nose a toad is presented.) The toad's hind-legs are short and weak, whence it is but little capable of leaping. (How does it usually move?) In harmony with its chiefly terrestrial habits, the swimming membranes between the toes of the hind-feet are thick and narrow. As an energetic destroyer of much noxious vermin, especially slugs, the toad renders most useful service to man, and deserves his protection.

In spring the pools and marshes of Central Europe are resonant with the ghostly bell-like notes of the **Bombinator**, which seem to proceed from the depth of the water. The colour of the back of this animal, which is not found in England, resembles that of the mud of the bottom (protective colouring). The belly, on the other hand, is very conspicuously marked by yellow (*B. pachypus*) or red (*B. igneus*) spots (hence called fire-bellied frogs). When surprised by an enemy and unable to seek refuge in the water, this animal bends back its head, folds its front-legs over its bent back, or turns over on its back and presents its bright-coloured under side to the enemy. It remains in this position until the danger is past, showing that here as in the case of the land salamander we are dealing with a "warning colour," since the bombinator, like the salamander, secretes a poisoning fluid from its skin.

The **Tree Frog** (*Hyla arborea*) is a favourite though very unreliable weather-prophet. It lives in reed-beds, bushes, trees, etc., where it hunts after all sorts of insects. Its colour frequently bears a striking resemblance to its surroundings. The usual colour of the animal is a leafy

Digitized by Google

green, but it may also assume an olive green, blackish-green, brown, grey, and almost white colour. When surprised by an enemy, the tree frog further protects itself by pressing its body close against a leaf or the trunk of a tree, from which in such cases it is scarcely to be distinguished. The animal is enabled to climb about on plants by means of adhesive or sucking discs on the ends of its toes. By pressing these as well as the whole under side of the body firmly against the underlying object, the tree frog maintains a very firm hold, being able to cling with safety even to swaying leaves or glass walls (power of adhesion). The call-note of the male, which sounds like "ēpp-ēpp," is intensified by a large vocal sac prominent on the throat. The tree frog winters beneath moss, in holes, or in the water, where its larvæ also undergo their development.

ORDER II.: TAILED AMPHIBIANS (URODELA).

Body elongated; always provided with a tail, with two pairs of limbs (the posterior pair absent in exceptional cases).

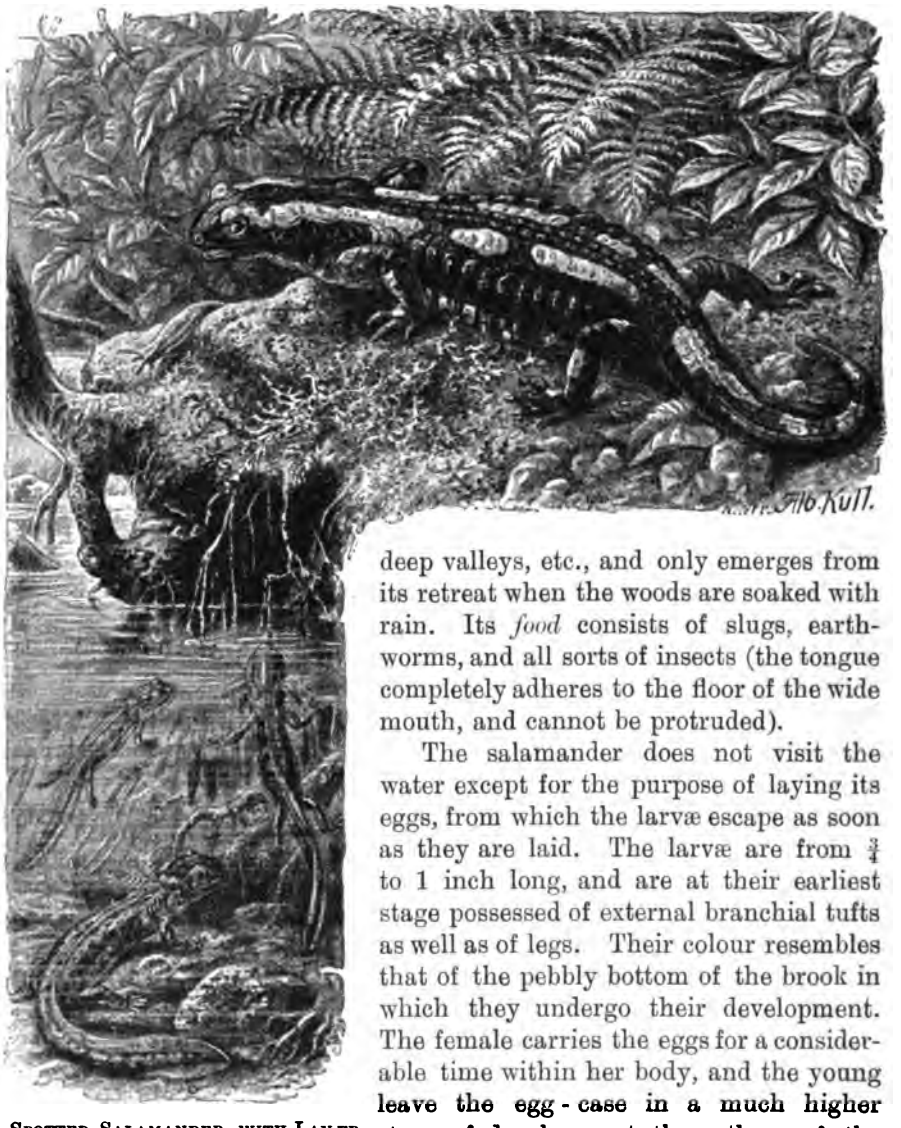
The Spotted Salamander (*Salamandra maculosa*).

(Length up to 9 inches.)

In most animals the body is of such a colour as to enable the creature to escape the notice of its enemies as far as possible. (Examples.) The colour of the salamander's skin, on the other hand, is in the highest degree conspicuous. This is, however, by no means a disadvantage to the animal, for its skin secretes an acrid, poisonous fluid, which has a fatal effect upon birds and small mammals. When the salamander is alarmed or pressed, this fluid is ejected in drops, and gives out a musk-like smell. (The fluid was formerly credited with the property of extinguishing fire, and in Germany this species is known as the "fire-salamander." It was once a superstition that the salamander could actually live in fire.) Its unfitness for food and poisonous properties would, however, be of little benefit to the animal after it had been seized or had received a mortal bite. It is here that its motley garment is called into requisition, acting as a danger-signal to the would-be assailant: "Don't touch me, for I'm poisonous." (Compare with gaily-coloured insects, which possess an evil smell and repulsive taste.) The salamander accordingly possesses no *enemies*, except the ringed snake, and its movements are therefore exceedingly slow. The body is *lizard-like in shape*, the *tail long* and round, and the legs *short*. The animal creeps along with snail-like speed by bending body and tail sideways, and then pushing itself forward with the legs. (Compare with the sand lizard.)

Digitized by Google

A dry heat soon proves dangerous to this as to all other amphibians. (Why? See p. 253.) Accordingly it chooses for its habitat damp woods,



SPOTTED SALAMANDER, WITH LAVÆR. (About one-half natural size.)

deep valleys, etc., and only emerges from its retreat when the woods are soaked with rain. Its *food* consists of slugs, earthworms, and all sorts of insects (the tongue completely adheres to the floor of the wide mouth, and cannot be protruded).

The salamander does not visit the water except for the purpose of laying its eggs, from which the larvæ escape as soon as they are laid. The larvæ are from $\frac{3}{4}$ to 1 inch long, and are at their earliest stage possessed of external branchial tufts as well as of legs. Their colour resembles that of the pebbly bottom of the brook in which they undergo their development. The female carries the eggs for a considerable time within her body, and the young leave the egg-case in a much higher stage of development than those of the frog. The perpetuation of the species is rendered sure by a much less numerous progeny, which rarely exceed forty. After the disappearance of the branchiæ, the development of

Digitized by Google

lungs, and the conversion of the swimming-tail into an organ of support, the young salamander leaves the water for the dry land.

Other Tailed Amphibians.

The little **Smooth Newt** (*Triton vulgaris*; see illustration below) is to be found during the spawning months in almost every pool. It is about 3 inches long, and of lizard-like shape. During the spawning season it sports a so-called "courting" or "wedding" dress. (Compare with birds; see p. 148.) The back and sides are olive-

SMOOTH AND CRESTED NEWTS. (Natural size.)

Smooth Newt.—M., male; W., female; 1, eggs within rolled-up leaves; 2, older eggs containing partially-developed larvæ; 3-7, successive developmental stages. *Crested Newt.*—K., male.

green or brown, with spots of a darker colour (corresponding to the colour of the bottom of the pond, etc.); the under side is lighter coloured, with longitudinal orange-coloured stripes. The male at this season is easily recognised by its broad dorsal crest, which extends uninterruptedly from

Digitized by Google

the neck to the extremity of the tail. The *legs* being short and weak, motion through the water is accomplished by means of the broad *swimming-tail*, which is completely surrounded by a fin-membrane (see larva of frog). The female lays its *eggs* singly in the protecting angles of the leaves of water-plants, or it bends or rolls up leaves, and then glues the eggs within the bend or roll. The development of the larvæ is much simpler than in the frog (observe it in an aquarium). Essentially it consists in nothing more than the loss of the external branchiæ and the development of lungs. Neither horny jaws nor internal branchiæ are developed, and the change in external shape is inconsiderable. (Why?) The fore-legs are budded forth in advance of the hind-limbs. The young leave the water when their development is complete, while the old newts quit it after the spawning season. The food consists of worms and insects.

PROTEUS IN WATER OF A SUBTERRANEOUS CAVERN.
(About one-half natural size).

The **Great Water or Crested Newt** (*T. cristatus*; see illustration, p. 263) is distinguished by a still more brilliant "courting-dress" during the breeding season. It reaches a length of about 6 inches. The male is distinguished by a dorsal crest with serrated edge, interrupted at the base of the tail.

A remarkable member of this division is the **Proteus Salamander**

Digitized by Google

(*Proteus anguineus*), which inhabits the water of subterraneous caverns in Carniola and Dalmatia. Passing its life in perfect darkness, the animal is completely blind (compare with mole), and its skin colourless (compare with tape-worm and cockchafer grub). The skin, being very thin, allows the blood-corpuscles (see Part I., p. 7) to be seen through the body walls, and the animal thus appears flesh-coloured. The feet are short and weak, and quite useless for locomotion, and the body is accordingly elongated and vermiform (see p. 232, Section 2). As the animal never leaves the water, it retains its swimming-tail throughout life, as well as external branchiæ, in addition to lungs; in short, it remains in the larval condition of the higher amphibians.

The **Mexican Axalotl**, which is often kept in aquaria, is a larval form which breeds in that condition in the Lake of Mexico. If forced to leave the water, however, it loses the external gills and the fin-membrane of the tail, and becomes a terrestrial form known as Amblystoma. In the United States the transformation occurs regularly.

Digitized by Google

CLASS V.: FISHES (PISCES).

AQUATIC vertebrates of variable body temperature (cold-blooded). Body usually covered with scales. Breathing by gills. Limbs, when present, having the form of fins; possessing also unpaired fins placed in the middle line of the body. Mostly oviparous.

1. **Form of Body.**—All fish *inhabit the water*. Their life is passed in a medium which cannot be divided with the same ease as the more fluid air. Accordingly, in all fishes, which—as is the case with the vast majority—on account of their predatory mode of life must be endowed with the capacity of rapid locomotion, the body is laterally compressed and tapering—often even pointed—at its anterior and posterior extremities; it bears, in fact, a strong resemblance to a spindle or the hull of a boat, and is therefore excellently adapted for cutting through the water. (Compare, on the other hand, fishes living on the bottom—eels, plaice, rays.) How is this spindle shape produced?

(*a*) The head and body are immovably united; a movable neck would, in fact, be an impediment to forward movement. (Why? See Section 2.) Nor is a neck required, fishes being able to move their head and body together with ease in any direction they desire.

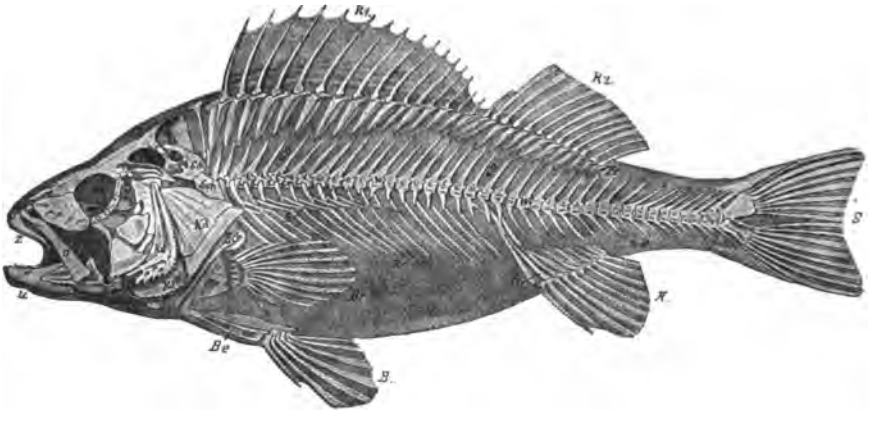
(*b*) In most vertebrates the *tail* is more or less distinctly marked off from the body (examples); in fishes, on the other hand, the body along its whole breadth passes gradually into the tail, which commences without any break at the posterior termination of the abdominal cavity (see Section 2, *b*).

(*c*) The *pectoral* and *pelvic* girdles, by which the breadth of the body in most other vertebrates is much increased at its anterior and posterior extremities, are in fishes very feebly developed. (Why? See Section 4.)

2. **Motion and Locomotive Organs.**—(*a*) The rudder and oars of a boat are provided with broad surfaces, for the purpose of enabling man to exert a strong pressure against the water. The limbs of fishes are constructed on a similar plan, presenting flat surfaces, while the portion connecting them with the trunk (*i.e.*, the handle of the oar) is usually

Digitized by Google

much shorter than the effective part of the organ. They are described as *pectoral* and *ventral fins*, and correspond to the front and hind limbs of other vertebrates. In addition to these paired fins, others are developed along the vertical median line of the body. In their simplest form (see eel) the fins present a continuous fringe or band. In most cases, however, this fringe is broken up by intervening gaps into separate segments, which are known as the *dorsal*, *caudal*, and *anal fins*. (Explain these names, and say in what fishes one or other of these fins is absent. Note the position of the ventral fin.) If the two lobes of the caudal fin are of equal size, the fin is described as symmetrical or *homocercal* (in most teleostean fishes); if the lobes are of unequal size, the fin is said to be asymmetrical or *heterocercal* (*e.g.*, in sharks and sturgeons).



SKELETON OF THE COMMON PERCH. (About one-fourth natural size.)

Z., Præmaxilla; O., maxilla; U., mandible; Au., orbit; Kd., parts of the operculum; Br., pectoral fin; Sch., bones of the shoulder girdle; Br., ventral fin; Be., pelvic bones; W., vertebral column; o.D., neural spines; u.D., hæmal spines; R., ribs; G., intermuscular spinous processes of ribs; Ft., interspinous bones; R1, first dorsal fin with spinous rays; R2, second dorsal fin with soft rays; A., anal fin; S., caudal fin.

The fins are expansions of skin, supported by bony or cartilaginous rays and connected with muscles, by the action of which they can be expanded or folded together, erected or depressed. If the rays are each composed of a single solid piece, they are known as "spinous rays" or spines; if, on the other hand, they are transversely jointed and divided longitudinally at their upper portions, they are known as "soft rays." (Examples.) The rays of the dorsal and anal fins are articulated with the so-called "interspinous bones," which are plunged between the muscles of the two lateral halves of the body, and interposed between the dorsal (neural) or ventral (hæmal) spines of the vertebræ (see Part I., pp. 3 and 4).

Digitized by Google

The rays of the caudal fin are firmly united with the posterior vertebræ (compare with the tail of birds).

(*b*) A fish is capable of floating at rest in any particular spot of its own selection. It follows, hence, *that its body is invariably of the same weight as the quantity of water which it displaces.* (What would happen if its body were heavier or lighter than this bulk of water?) The fish being thus *supported by the water*, its limbs do not require to be strong, especially as they take no considerable share in the animal's locomotion (see Section 2, *d*). (Contrast their function in this respect in most other vertebrates.)

The most important organ of locomotion is, in fact, the tail and its fin. If we watch a fish suddenly darting forward from a position of rest, we notice that it is the tail and caudal fin which are called into action, and not the limbs, while in the case of a fish rapidly swimming along, the forward movement results from alternate right and left strokes of the same organs. We may get some idea as to the *manner in which this motion is effected* by watching a kind of rowing often employed in harbours and by watermen, which is called sculling. Here the oarsman standing at the end of the boat handles a single oar, which rests in a notch in the edge of the boat, moving it with a twist from left to right, and *vice versâ*. At each stroke the oar exerts a pressure directed obliquely backwards against the water, which has the effect of pushing the boat a certain distance forwards. In a similar manner the fish propels itself forwards by twisting, sideward strokes of its tail.

The importance of the tail as an organ of propulsion also explains its size and strength. (Compare with the tail of other vertebrates, and consider also the action of this organ in lizards, snakes, and tailed amphibians.) Hence the tail of fishes is formed—apart from the vertebral column, which forms its central support—exclusively of *muscles*, which extend forward in four large bands as far as the head. (Separate these muscular bands in a cooked fish or red-herring.) The two stouter of these bands lie along the back, the thinner ones at the sides of the body and tail; and all of them are composed of a large number of transverse muscular segments (myotomes), which fall away from each other when the fish is boiled. (Where are the largest muscles situated in other vertebrates, and why?) The force exerted by these muscles is very considerable. Thus, a salmon is able to accomplish a distance of from 24 to 27 feet per second, and can leap over weirs and waterfalls up to 13 feet in height. (How does a fish behave when it happens to get thrown upon dry land?)

If it desires to alter its course, the fish bends its body into a curve, so that head and tail are pointed towards the side it wishes to go.

Digitized by Google

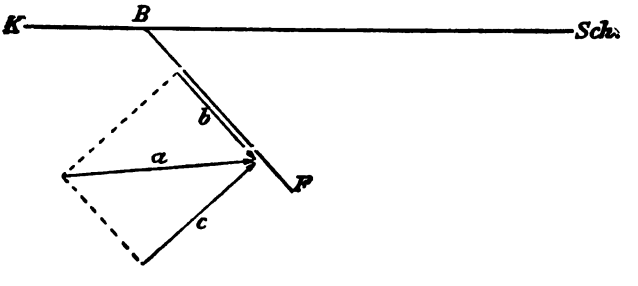
The whole body thereupon follows the direction assumed by the head.

(*c*) Since the back is the heaviest part of a fish's body, the animal, while swimming, is always in a condition of unstable equilibrium. (Hence, what is the position assumed by a dead fish?) It must, therefore, constantly balance itself (as man does unconsciously in standing), in order to prevent itself from turning over on to its back. This is effected by the action of the *dorsal* and *anal fins* (as well as by the vertical caudal fin), all of which increase the vertical surface of the body, and thus help to maintain it constantly in a vertical position in the water (compare with a ship's keel). By virtue of their position, these fins cut through the water with ease. During rapid progression they are laid back. (Why?)

(*d*) The *pectoral and ventral fins* have varied uses. When swimming slowly, the fish employs them as *oars*. (Why are they laid back in rapid swimming?)

Next, they serve for steering. Thus, if a fish at rest wishes to swim over to the right, it has only to execute a few strokes with the left fin; on the other hand, if a fish swimming in a straightforward direction wishes to turn to the right, it lays its left fins close up against the body, and expands those of the right side. By this action (just as in a boat steered by the oars) the speed of the right side of the animal's body is impeded, and the body accordingly constrained to turn towards the right.

Again, the pectoral and ventral fins effect the *ascent* and *descent* of the fish in the water. If a fish swimming in a horizontal position (let line K Sch. represent the body of the fish, K the position of head, Sch. the tail) desires to rise, it places its pectoral fins (B F) obliquely backwards, so that their anterior edge comes to lie higher than their posterior edge. (Place your arm and hand in this position.) As a result of the forward movement effected by the caudal fin, the water tends to impede the pectoral fins. This is exactly as if a force (*a*) directed parallel to the body of the fish were impinging on the under, or what is now the anterior, surface of the fins. This force, acting obliquely on the surface of the fin, is resolved (exactly as in avian flight, which see),



Digitized by Google

according to the parallelogram of forces, into two component forces, of which one (*b*) is ineffectual, whilst the other (*c*) impinges on the fin in a vertical direction, and thus *raises the fore part of the fish's body*. On the other hand, if the fish wishes to sink, it places its pectoral fins in a reverse position, viz., obliquely forwards (illustrate this for yourself by an appropriate drawing). Finally, the pectoral and ventral fins also aid the fish in maintaining its *equilibrium*; this is proved by cutting off the pectoral, or both the pectoral and ventral fin of one side of the body, when the fish will turn over to this side, since it now, as it were, forces the body over to this side by means of the two still remaining fins.

An organ playing an important part in locomotion is the—

3. **Air-bladder.**—An air-bladder is present in most fishes (see illustration, p. 274). It consists of a membranous sac placed beneath the vertebral column above the abdominal cavity, and is either completely closed or communicates with the digestive canal by means of a passage, the so-called air-duct (ductus pneumaticus). It consists of a single sac or of several segments (two in the carp family), and is always inflated with air, which is secreted from bloodvessels.

It is somewhat difficult to understand completely the action of the air-bladder. There can be no doubt that its presence reduces the specific gravity of the body of the fish, so that it is nearly the same as that of the water, and has little tendency either to rise or sink. If the air-bladder were surrounded by rigid walls, like a cask or a hollow glass ball, the bulk of the fish would remain the same at any depth, and therefore its specific gravity would remain the same. But the air-bladder and the body walls of the fish are not rigid, and therefore the size of the air-bladder varies with the pressure of the water. The pressure of the water increases with the depth, and supposing the fish lifeless, when it was placed at a greater depth the air-bladder would be reduced, therefore the bulk of the body would be decreased and the specific gravity increased. Thus the fish would begin to sink, and the further it sank the more its specific gravity would increase. Conversely, if the lifeless fish were taken to a higher level, the air-bladder would expand and the fish become specifically lighter. The fish would thus begin to rise, and the higher it rose the more its specific gravity would decrease. The lifeless fish is therefore in the same condition as the hydrostatic apparatus known as the Cartesian diver, which is merely a little figure containing an air-bladder. The figure sinks in water when the pressure is increased, rises when it is decreased. This explains why, if a fish be suddenly brought to the surface from a considerable depth, the air-bladder expands so much that it projects through the mouth, driving the gullet before it, and the fish is unable to get below the surface again.

Digitized by Google

When a fish is alive, however, it can compress or expand its air-bladder by the action of its muscles, and therefore rise and sink at will within certain limits. If it sinks too far, however, the pressure of the water may be so great that the air-bladder cannot expand sufficiently to cause it to rise again, and if it rises too far the pressure of the water may be so slight that it cannot compress its air-bladder again. We do not know how far the living fish may be able to accommodate itself by increasing or decreasing the *quantity* of air in the air-bladder. We know that many bottom fishes, like the plaice and sole, and all the Selachii, are destitute of an air-bladder.

4. The **Skeleton** is bony in the larger number of fishes, the bony fishes, or *Teleostei*. In the other orders (which see) it remains cartilaginous throughout life. We shall here confine ourselves to the former of these orders.

(*a*) The body of a fish being of nearly the same specific gravity as the water, and accordingly supported by the latter, it follows that the bones which compose the vertebral column and limbs are far weaker than those of land animals or birds, who have to support the weight of their own body. For the same reason the pectoral and pelvic arches also are only feebly developed. The former of these, as a rule, is connected with the skull; the latter is composed of a single bone, which is never connected to the vertebral column. These conditions, and the absence of a neck, also explain the remarkable uniformity of the vertebral column, in which only two segments, an abdominal and a caudal segment, are distinguishable. The abdominal segment is usually characterized by the presence of a large number of *ribs*, which form a protecting framework for the abdominal cavity and the viscera. Embedded among the large dorsal and lateral muscular bands are also to be found generally a larger or smaller number of bones, the intermuscular spinous processes of the ribs. In correlation with the mode of progression of fishes, we find that the vertebral column, and especially its caudal segment, is very flexible from side to side. All the vertebræ present conical cavities at both ends, being biconcave or amphicœlous, and only in contact with each other at the outer margins of these cavities. (For the fin rays and interspinous bones refer back to Section 2, *a*.)

(*b*) The limbs of fishes not being adapted for the seizing of their prey, this task is necessarily performed (as in snakes) by the mouth. The anterior, facial portions of the skull, *i.e.*, the *maxilla and the premaxilla*, are protrusible to a considerable extent, as may be easily observed in such fish as the carp. (Compare, on the other hand, the shark. Premaxillary bones occur also in the other classes of vertebrates; in mammals they carry the incisor teeth.) *Teeth* are present in all parts

Digitized by Google

of the mouth; but as a constant stream of the water used for respiratory purposes is maintained through the oral chamber, the food cannot be subjected to mastication in the latter (discuss this more fully). Hence the teeth can only be employed for holding the prey or biting or tearing off morsels. (Why are not the teeth of various forms, as in mammals?)

(*c*) The *gill-covers* (opercula), which consist of several bony pieces, and the *branchial arches*, will be treated more fully in Section 5. We shall here only note the following important points: The portions of the branchial arches which come in contact with the skull are commonly beset with larger or smaller teeth, and from the fact of their lying in the upper wall of the *pharynx* are known as the *superior pharyngeal bones*. Similarly, the fifth pair of branchial arches which do not bear gills carry teeth on their inner surfaces. The bones of this arch perforate the throat from below, and are hence termed the *inferior pharyngeal bones*. The pharyngeal bones, with their equipment of teeth, are used for holding the prey while it is being swallowed; it is only in the carp family (see carp) that they function as true organs of mastication.

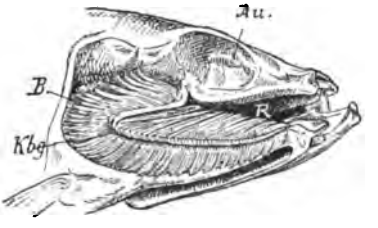
INFERIOR PHARYNGEAL BONES OF THE CARP.

5. **Respiration and Circulation.**—If water be allowed to stand in a glass for a considerable time, small vesicles of air will be observed to congregate upon the sides of the glass, showing that the water really contains air. If a fish be brought into water which has been allowed to stand in this manner, or from which all air has been expelled by boiling, it will die in a short time; it expires from want of fresh air—is suffocated, in fact. Mammals, birds, or reptiles are not capable of breathing air thus dissolved in water, like a fish, for the latter possesses in its *gills* or *branchiæ* organs specially adapted for "aquatic respiration." Let us now examine the structure of the gills and the process of branchial respiration in one of our most familiar fresh-water fish—*e.g.*, the perch or carp.

(*a*) On opening the mouth of one of these fish, it will be seen that the walls of its posterior portion are perforated on each side by four cleft-like apertures, the so-called *branchial clefts*. The walls between these clefts are each supported by a bone, the so-called *branchial arch*. A similar branchial arch is placed in front of the first and behind the last branchial cleft. The outer margin of each branchial arch (excepting the fifth; see inferior pharyngeal bone, Section 4, *c*) carries two rows of very fine, lancet-shaped leaflets, the branchial laminæ, whilst their inner

Digitized by Google

margin, in most bony fish, is beset with horny teeth or spines, forming the so-called *gill-rakers*. The function of these processes is to intercept any solid foreign bodies which may have been taken in with the water of respiration (see herring), and to prevent their coming in contact with the branchial leaflets. In the teleostean and ganoid fishes (compare, however, sharks, rays, and lampreys) the branchial leaflets are outwardly protected against injury by the bony *gill-cover*, or *operculum*. The posterior edge of the operculum is free, leaving an aperture, the *gill opening*, between it and the body wall.



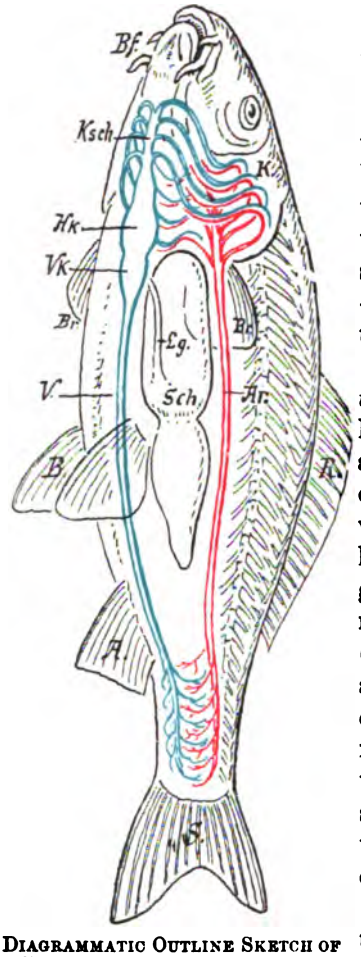
HEAD OF A FISH (HERRING), OPENED TO SHOW THE GILLS.

Kbg., gill-arches; B., branchial laminæ; R., gill-rakers; Au., eye-socket.

(*b*) Let us now examine *how respiration—i.e.*, the exchange between poisonous carbonic acid and the restorative oxygen—is *effected*. Immediately behind the gills, in the region of the throat, is situated the *heart*, which consists only of an *auricle* (Vk) and a *ventricle* (Hk). The blood, loaded with carbonic acid (venous blood) after passage through the whole body, enters the auricle, thence passes into the ventricle, from which it is pumped into a vessel which passes forwards, the *branchial artery* (Ksch). This artery gives off on each side as many branches as there are branchial arches. One of these branches (K) passes off to each branchial arch, and again sends off a secondary branch (1) to each of the branchial leaflets (see illustration on p. 274). The latter ramifies on the inner surface of the branchial leaflets, and is finally resolved into capillaries. We have now two kinds of air separated by the thin membrane of the branchial leaflets—viz., the carbonic acid gas in the blood, and the oxygen of the atmospheric air, which is dissolved in the water which bathes the gills. Hence, as in the lungs, a mutual exchange of the two gases is effected (see Part I., p. 6, Section 5). The carbonic acid passes through the fine membrane out into the water, while the oxygen passes in a reverse direction from the water into the blood. The blood thus purified (arterial blood) is collected in a vessel (2) running along the outer edge of the branchial leaflet, and is thence conveyed into a larger vessel (3)—branchial vein—which runs along the branchial arch, and which also receives the oxygenated blood from all the other branchial leaflets of the same arch. The branchial veins of all the gills, filled with arterial blood, unite to form a large vessel, the dorsal aorta (Ar.), which is continued backwards below the vertebral column, and, ramifying into all the different parts of the body,

Digitized by Google

supplies them with arterial blood. This blood, after giving up its oxygen (see Part I., p. 7, Section 6) and receiving carbonic acid gas in exchange, once more returns (V.) to the heart, thus completing the circulation.

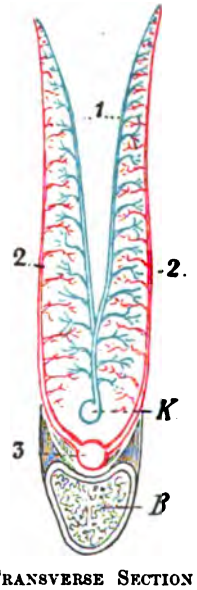


DIAGRAMMATIC OUTLINE SKETCH OF A FISH (CARP), SHOWING THE CIRCULATION OF THE BLOOD.

Bf., barbels; Br., pectoral fins; A., anal fin; S., caudal fin; R., dorsal fin; Sch., swimbladder; Lg., pneumatic duct of swim-bladder. The other letters are explained in the text.

(*c*) As the water which bathes the gills is deprived of its oxygen, it *requires to be constantly renewed*. This is effected in the following manner: After being taken in by the mouth, the water is pressed through the branchial clefts, and after having bathed the branchial leaflets is expelled through the gill-slits. (For the course of the respiratory current in rays—also many sharks—the lamprey and the lancelet, see under the respective species.)

(*d*) Fish soon die *out of the water*, although they have at their command a much larger quantity of oxygen than in the water. The branchial leaflets dry up, stick together, and get entangled, respiration is arrested (for air only penetrates animal membranes with ease when these are moistened—compare with the cutaneous respiration in amphibians), until finally the animals die of *suffocation*.



TRANSVERSE SECTION THROUGH A BRANCHIAL ARCH, WITH TWO OF THE BRANCHIAL LEAFLETS, SHOWING THE CIRCULATION OF THE BLOOD (DIAGRAMMATIC).

B, branchial arch. The other references are explained in the text.

(*e*) It results from the simple structure of their heart, the slow circulation and branchial respiration, that the *body temperature* of fishes *varies with that of the surrounding medium*; whereas in all other vertebrates the blood courses twice through the heart, the circulation thereby receiving a double stimulus, the simple heart of the fish imparts to the blood only a single impulse to circulate.

Digitized by Google

Hence the blood flows slowly through the body. This may be shown by making an incision behind the gills into the branchial artery of a fish, when the blood will be found merely to *flow* from the wound, whereas if an artery is opened in any other vertebrate animal the blood is spurted forth with great energy. Even with a more active circulation, fish could not be warm-blooded animals, since the water which constantly bathes the gills withdraws so much heat from the blood that a large quantity of heat would be required to raise the temperature of the blood above that of the surrounding water. (Compare warm-blooded aquatic animals and their special provisions for the conservation of heat.) This, however, is impossible, for fishes can only draw upon a small supply of oxygen in the water, 1 cubic metre of water containing only about 20 grammes of oxygen, without which life is impossible, as against 300 grammes contained in a cubic metre of air. In proportion, however, as the circulation is slackened, and the quantity of oxygen taken up by the blood diminished, the assimilation of food materials, and the bodily heat which is thereby called forth (see Part I., pp. 7 and 8), as well as the total mental activity of the animal, are correspondingly reduced.

Like all animals whose body temperature is subject to variation (see p. 229), fishes are most active during the warm season of the year. On a summer's day they may be seen playfully disporting themselves in the warm water of our rivers and lakes. In the winter they retire to the deeper and warmer strata of the water, and there pass through a kind of *hibernation*; some even bury themselves in the mud.

6. **Body Coverings.**—Cold-blooded creatures like fishes do not require any heat-retaining covering. (Why? See p. 229.) Their body is generally covered with scales; in some rare cases large horny plates are developed in the integument, whilst in others the skin is perfectly naked. (Give examples. See also the scales of sharks.) When these scales overlap in the manner of tiles, they are invariably directed backwards, so as not to impede the animal's progress. The *mucus* secreted by the skin and covering the surface of the body has a similar import, but also serves as a means of protection against enemies. (Why? Compare, however, the teeth and beaks of animals which prey on fish.)

Like many reptiles and amphibians, which are capable of adapting their colour to their surroundings, many fishes also are endowed with the faculty of assimilating the colour of their skin to that of the ground over which they swim. Even under a small magnifying power we may distinguish in the scales of a perch or carp the pigment cells (see p. 253) by which these changes are effected.

7. **Organs of Sense.**—The *eye* is constructed on essentially the same plan as in mammals (see Part I., p. 12). In the water, even at the

Digitized by Google

depth of a few fathoms, semi-darkness prevails, consequently the eyes of fishes are generally remarkably large and their pupils very broad. (Compare with nocturnal animals, *e.g.*, owls and cats.) In animals that live in the air the cornea is convex like a watch-glass, and, together with the aqueous humour between the cornea and the iris, has a strong refractive action. In the eye of a fish, on the other hand, the refractive power of the cornea is about the same as that of the water, and the surface of the cornea is therefore flat. Refraction in the eye of the fish is chiefly due to the lens, which is almost spherical. When a fish is boiled the lens becomes opaque, and then appears white. Eyelids which in other vertebrates protect the eye from external injury, especially from dust, are generally wanting in fishes. For this reason it is all the more important for them that the cornea does not project from the surface of the body.

The *ear* of fishes is a very simple structure. Neither external ear, auditory passages, tympanum, or auditory ossicles are present, the sole functions of these organs being to catch the waves of sound and transmit them to the fluids of the auditory labyrinth (see Part I., p. 13). The fish, however, can dispense with organs of this nature (compare with seal and whale), since the waves of sound, which are propagated in water with great ease, produce vibrations in the bones of the skull, which are transmitted to the fluid of the labyrinth.

The *nose* does not, as in air-breathing animals, take any share in the function of respiration, hence it does not open into the interior of the oral cavity, but consists merely of two pits placed at the front end of the head, in which the water streams freely in and out.

The whole of the integument functions as an *organ of touch*, the skin of the lips, however, being more specially sensitive to tactile impressions, and provided in many "bottom fishes" (sheat-fishes, tench) with fleshy tactile filaments, or "barbels."

The *sense of taste*, which has its seat in the mucous membrane of the mouth, is but slightly developed.

SCALE OF THE LATERAL LINE OF A ROACH, SHOWING THE CANAL.

In many fishes (take a perch, for instance) a peculiar dark line may be observed running along the middle of each side of the body from head to tail. This is the so-called *lateral line*. Each of the scales in this line is perforated by a tube opening on its surface and leading down to a longitudinal canal which runs underneath the lateral line, and is provided with peculiar bodies which have all the appearance of sense organs. Indeed, naturalists are of opinion that they represent the organs of a sixth sense, unknown (and absent) in ourselves. Possibly this sense renders the fish cognizant of any excessive pressure of the water, since

Digitized by Google

either deficient or excessive pressure is as dangerous to fish as it is to man. (What happens when surface fish sink to too great a depth or deep-water fish rise too near the surface? See air-bladder.)

8. **Reproduction.**—All fish, with the exception of a few species, which, like the blue shark, bring forth living young, are *oviparous*. The number of eggs deposited by the female is immense; nor is the reason of this difficult to understand when we consider that the parents take no further interest in the fate of their eggs after they have deposited the spawn, that thousands of eggs and young fish are destroyed by fish of the same or other species, or other predaceous animals; whilst, lastly, an incessant internecine war of extermination is constantly being waged amongst the fishes themselves, in spite of their peaceful appearance and demeanour. In some fish, *e.g.*, the cod, the eggs deposited by one female amount to several millions. Man also takes no small share in the destruction of fishes. Many millions of people live year in, year out, from the capture of fish and the various industries connected with this calling. Several species *nurture their young* (give examples). The young, after they leave the egg, in many cases (*e.g.*, eel and lamprey) pass through a series of developmental changes (metamorphosis), such as we saw among the amphibia.

ORDER I.: BONY FISHES (TELEOSTEI).

Skeleton bony, the vertebræ separate. Skin, as a rule, furnished with true scales. A gill-cover (operculum) always developed.

Sub-Order 1: Air-bladder provided with an Air-duct (*Physostomi*).

The Carp (*Cyprinus carpio*).

(Length generally 12 to 17 inches. See illustration, p. 274.)

A. Habitat and Range.

The native home of the carp is probably in the temperate parts of Asia. On account of its well-flavoured flesh, however, man has extended the range of this fish over a great portion of the earth, and in many places (Germany and America) it forms the principal object of fish culture. Its wide distribution under the most varying conditions of life, and the fact that it can be bred like a domestic animal (see dog), have led to the development of numerous breeds or varieties. Of the latter we need only mention the **Smooth** or **Specular Carp**, with a few large scales, and the **Leather Carp**, which is perfectly devoid of scales (explain the names).

Digitized by Google

The mode in which it is adapted to an *aquatic life* is evident from what has been already stated under this head in our general remarks on fishes.

B. Structure of Body, and Food.

The carp is by no means a fastidious feeder; indeed, it will consume anything that is eatable: portions of green plants, mud with its various decaying and putrefying materials, worms, insects and their larvæ, snails, small fresh-water crustacea, which often occur in ponds and rivers in enormous quantities (*Copepoda*)—see herring and illustration, p. 285—and so-called "water fleas" (*Daphnia*)—which see—and anything else, in fact, which may be found in the water. Domesticated carp are fed with all sorts of kitchen refuse, peas, beans, etc. The carp, in fact, is omnivorous, "the pig among fishes." (How far is this omnivorous habit an advantage to the distribution of the fish, and of importance to its artificial culture?)

(*a*) The carp, accordingly, is not obliged to be a rapid swimmer, like a predaceous fish, *e.g.*, the pike (which see). Hence its body is relatively stout (prove this more fully). Carp reared artificially are higher-backed, and consequently more fleshy, while those living in a state of nature are longer and narrower (explain this difference).

(*b*) Slow motion from place to place is effected primarily by the *pectoral fins*, which accordingly have the form of large broad oars.

(*c*) The carp, not being obliged to seize, hold, and swallow large-sized prey, has a narrow and *toothless mouth*. (With regard to protrusibility of jaws, see p. 271, Section *b*.)

(*d*) Vegetable substances, in order to be digested, require to be masticated (see Part I., p. 102, Section 2). In the carp mastication is effected by means of the *pharyngeal bones*. The superior pharyngeal bones, accordingly, have the form of broad plates, while the inferior ones are armed with teeth, having broad crowns surmounted with folds of enamel. (Compare with herbivorous mammals.) The posterior part of the oral cavity, the *masticatory chamber*, in which the food is divided up, is closed by muscles both at its anterior oral and its posterior pharyngeal termination. (Why is this necessary? Remember what was said about the water of respiration which streams through the mouth.)

(*e*) The *intestine* is long, as in all herbivorous animals (see Part I., p. 102, Section 1, *f*).

(*f*) The mouth is surrounded by *fleshy lips*, and furnished with from two to four "barbels" on the upper lip, which serve as tactile organs in the searching of the mud.

(*g*) The predominance of vegetable substances in the food of the carp

Digitized by Google

also explains why this fish frequents by preference waters which are richly provided with plants. Here, however, it finds also an abundance of animal food, for an exuberant plant life always carries a rich animal life in its train (give proofs). A further *sine quâ non* in the selection of its habitat is the presence of deep portions which do not freeze over, and in which the fish can hibernate.

INFERIOR PHARYNGEAL BONES OF THE CARP.

C. Enemies.

From the egg down to its death this peaceful fish is encompassed by dangers. Otters, rats, water-shrews, sea-eagles, herons, and many other aquatic birds, as well as predaceous fish, incessantly pursue it. Its smaller-sized enemies have to content themselves with young fish, but the larger and stronger of its foes can overpower fish weighing many pounds. (The carp attains to a good age, and a weight of above 66 pounds. The so-called "grey-beards" among the carp are very old fish, the bodies of which are covered with a parasitic growth of algæ or fungi. How are such growths correlated with the slow and lazy habits of the fish?) The carp is a *defenceless* animal, being utterly unequipped with weapons of defence (proof).

(*a*) The *dorsal* and *anal* fin carry each in front a sharp, toothed spine; this, however, cannot be rigidly erected (see stickleback), and hence is of no importance as a defensive weapon.

(*b*) As in the majority of fish, in the carp also the upper side of the body is of a far darker *colour* than the under surface. Hence, when viewed from above (by enemies in the air and the upper strata of the water) the fish cannot easily be distinguished from the dark bottom, and seen from below (by enemies at the bottom and in the lower strata of the water) presents but a slight contrast against the bright sky. Nevertheless, this double coloration (back blackish-grey to blackish-brown, sides and belly mostly yellowish) affords it but slight protection against its keen-sighted enemies. A more effectual means for the preservation of its species rests upon its great

D. Fecundity.

According to calculations, a large female deposits as many as 700,000 eggs at one spawning. (Explain the importance of this strong reproductive power in the artificial culture of this fish.)

Digitized by Google

Other Members of the Carp Family.

The number of species of this family which inhabit our larger waters is very considerable, and they are often only with difficulty to be distinguished. We shall confine ourselves to mentioning the following:

The **Crucian Carp** (*Carassius vulgaris*) so closely resembles the common carp in all respects that it might be described as a "carp without barbels." An artificial variety of this species is the well-known **Gold-fish**, which originates from China, the land of fish culture *par excellence*.

The genus *Leuciscus* contains a very large number of species, most of them living in the open water, and hence silver-coloured (see herring), and not equipped with barbels like bottom fish (compare with carp, tench, etc.). Being chiefly carnivorous, they are nimbler swimmers than the carp (body being often laterally compressed), and their pharyngeal teeth have pointed crowns (compare with carnivorous mammals).

The best-known species are the **Roach** (*L. rutilus*), with its bright red iris, and the **Rudd** (*L. erythrophthalmus*), in which the iris is of a brilliant gold colour. The fins in both species are generally red.

A similar fish, but with much higher body and grey fins, is the **Bream** (*Abramis brama*), which reaches a length of 28 inches.

The **Barbel** (*Barbus vulgaris*) is of slender shape, and is a chiefly nocturnal bottom fish which feeds upon the smaller aquatic animals. The mouth is provided with four thick barbels. The numerous teeth of the inferior pharyngeal bones are sharp as in predaceous mammals. The roe is sometimes poisonous.

In pure waters with a sandy bottom in Germany occurs a little fish only about 2 inches long, called, on account of the bitter taste of its flesh, the **Bitterling** (*Rhodeus amarus*). In the spawning season the male shines with all the colours of the rainbow, and in the female there is a tubular appendage about 1½ inches long in front of the anal fin. This appendage is an "ovipositor," by the aid of which the female places her eggs in the interior cavity of a fresh-water mussel (*Unio* or *Anodon*). Between the gills of the bivalve the delicate eggs and young of the fish obtain protection and a constant circulation of water.

The **Tench** (*Tinca vulgaris*) frequents by preference a muddy bottom, in which it burrows after all kinds of decaying animal and vegetable substances. Correlated with this mode of life are its dark colour and the fleshy lips, with their barbels and broadly-crowned pharyngeal teeth (see carp). Unfortunately, this much-esteemed food-fish is daily becoming scarcer. (What is probably the reason of its disappearance?)

Digitized by Google

Another denizen of the muddy bottom is the **Spiny Loach** (*Cobitis tænia*). Its elongated, eel-like body is accordingly also dark-coloured (leather yellow to brown), and its mouth equipped with (six) barbels. This fish, especially when living in water poor in oxygen, frequently comes up to the surface in order to take in air with its mouth. The air thus swallowed is deprived of its oxygen in the intestine (intestinal respiration).

The **Groundling** or **Loach** (*C. barbatula*) is very similar, but rather larger; it lives in clear, running waters.

The Pike (*Esox lucius*).

(Length up to about 3½ feet.)

The pike is undoubtedly the most dreaded *pirate* of our waters, swallowing every aquatic creature it can master, and not even sparing its fellows of its own species.

(*a*) When fully grown (weighing then sometimes over 30 pounds) its *size and strength* are such as only few fishes (salmon and sheat-fish) can resist.

(*b*) During the day the pike may be seen in a motionless attitude among water plants. In its retreat it is rendered inconspicuous by the greenish *colour* of the back and sides of the body, the latter being crossed by several dark transverse bands or spotted with black.

(*c*) Swift as an arrow the fish darts upon its prey. (Why must the pike be a *rapid swimmer?* Compare it with predaceous members of other classes of animals.) Its elongated *body* and sharply-pointed *head* enable it to cut through the water with great speed. (Describe its fins.)

(*d*) The *mouth* is shaped like a duck's bill, with a wide gape extending up to the eyes, in which the victim is rapidly seized, and from which escape is impossible, for the mouth of the monster literally bristles with

(*e*) *Teeth.*—Some of the teeth are curved backwards (compare with snakes). After being severely wounded by the larger two-edged fangs which are scattered among the smaller so-called "hackle-teeth," and which penetrate deeply into the flesh, the victim is liberated for a moment, in order to be seized afresh and swallowed alive with the head foremost. (Why?)

(*f*) The *pharynx* is wide, and the *pharyngeal bones* are armed with teeth, while the *œsophagus* is very dilatable.

(*g*) The *intestine*, as in all carnivores (see cat), is short and muscular. (Compare the pike with the carp in regard to these various points.)

(*h*) *Importance to Man.*—The flesh of the pike is much esteemed as food. Naturally, the pike is kept carefully away from ponds which are

Digitized by Google

stocked with young carp. On the other hand, it is a welcome guest in waters inhabited only by inferior fish, the poor flesh of which it converts into its own valuable meat.

The Sheat-fish (*Silurus glanis*).

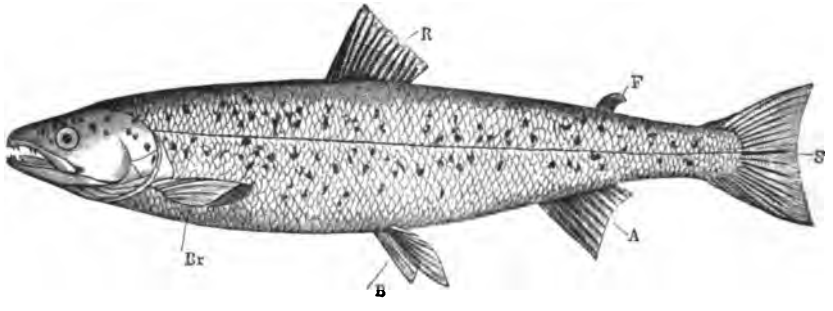
(Length up to 13 feet.)

Its dark-coloured, elongated, scaleless body and the long barbels characterize this fish as a denizen of the muddy bottom (see tench and carp); while its size, strength, rapidity, as well as the wide mouth, with its powerful equipment of teeth, give evidence of its rapacious habit (see pike). The great sensitiveness of the barbels compensates for the feeble sight, the eyes being extremely small. While lying motionless at the bottom, the barbels are moved about like writhing worms. May they not serve the purposes of bait for attracting the prey? The flesh of this fish is not highly esteemed. It does not occur in Britain.

The Salmon (*Salmo salar*).

(Length up to 5 feet.)

The salmon is an inhabitant of the coasts of the North Atlantic. Like the pike (which see), it is carnivorous in its habits. The salmon, however, chases its prey in open water, instead of stalking it at the bottom like the pike. Hence also its body is of *bluish-grey* colour on the back, while the sides and belly are silvery white (compare with



SALMON. (About one-fifteenth natural size.)
Br., Pectoral fin; B., ventral fin; A., anal fin; S., caudal fin; R., dorsal fin; F., adipose fin.

herring). Behind the dorsal fin there is an additional small rayless fin (adipose fin). The young are mostly ornamented with black dots and dark transverse bands (compare with perch and pike). The eggs require for their development clear, cool, running water, which is, moreover,

Digitized by Google

rich in oxygen. Hence the salmon, before depositing them, undertakes regular *migrations* from the sea to the clear, cool woodland streams and brooks. At certain times of the year (on the Rhine in May) it enters the larger rivers, travels up-stream, and then goes up their tributaries until it reaches a suitable spot for spawning. Its great bodily strength enables it easily to leap over weirs and waterfalls up to the height of 13 feet. Should higher obstacles bar its way, artificial structures called "salmon ladders" are provided for facilitating the ascent. These are placed by the side of the obstacles, and consist of slanting gutters or chutes, up which the fish can swim, or of reservoirs placed stepwise above each other, so that the salmon can leap from one to the other. After depositing the eggs, the salmon once more turns its course towards the sea, whither it is followed by the young fish; these, however, return to the place of their birth as early as in their second year, for the purpose of spawning in their turn. The salmon (like the trout) produces very large eggs, but the number of eggs is on that account much less than in most other fish (see carp), for the quiet pools in which they are deposited are free from that violent incessant war of extermination which prevails in the larger waters. The flesh of the ascending or fresh-run salmon is of a pink-red colour, and highly esteemed both fresh and in a smoked condition.

A valuable member of the salmon family is the merry **Trout** (*S. fario*), which all the year round inhabits woodland streams, brooks, and ponds traversed by running watercourses. The scaly coat of this fish is generally of a brassy yellow colour, ornamented with numerous black and red blue-bordered spots. In very shady brooks the trout is always darker than in those which are exposed to the sunshine, and the colour of the fish pales or darkens when it is transferred from the one kind of water into the other. (Explain the significance of this.) By its body structure the trout is a predatory fish, which lives by the incessant pursuit of all the smaller kinds of aquatic animals.

The Herring (*Clupea harengus*).

(Length 8 to 13 inches.)

A. Importance to Man.

Next to the cod, the herring is the most valuable product of the Northern seas. To it Holland and the Hanseatic League largely owed their former wealth and power (whence the saying, "Amsterdam is built on herrings' heads"); and even at the present day hundreds of

Digitized by Google

thousands of people still depend for their living entirely on this fish (fishermen, shippers, merchants, shipbuilders, coopers, etc.). Everybody in Northern or Central Europe is acquainted with the fish in some form or another, either in the fresh state (fresh herring), or salted, or pickled, or smoked (red herring, kipper), or marinated, *i.e.*, fried and then placed in vinegar. Young herrings before they have spawned are known in Germany as *matjesherringe*, from the Dutch word *maatje*, which means literally little mate, little fellow, that is, youngster; and this word is the origin of the Scotch term "matties." The adult

HERRING AND (ON THE LEFT BELOW) SPRAT. (About one-third natural size.)

herrings are called "full herrings" when their body cavities contain large roes or milts, and "spent herrings" when they have spawned. The roe of the female is generally called "hard roe," and the milt of the male "soft roe"; while fishermen call the female a "spawner," the male a "milter."

B. Habitat.

The herring is met with at some time of the year in all parts of the Northern seas. Being so widely distributed, it is not surprising to find

Digitized by Google

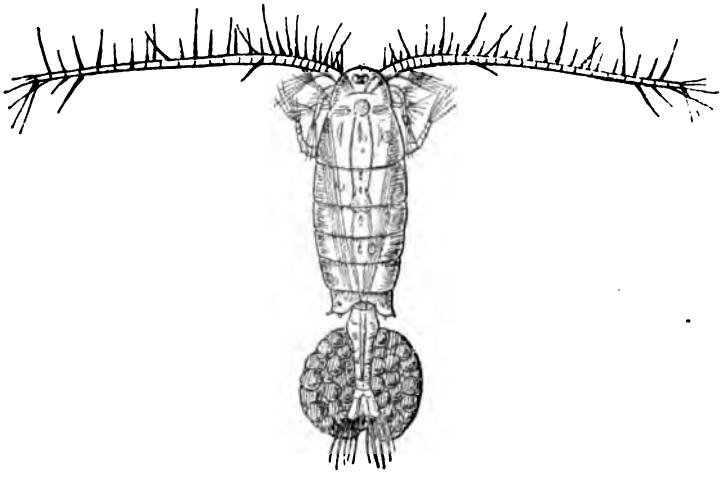
that the fish exhibits many deviations in its body structure (as, indeed, is the case in all widely-distributed animals, *e.g.*, lions, domestic animals). Naturalists accordingly distinguish races or varieties of herrings, comprised within two groups—viz., *deep-sea* and *littoral* herrings. The former inhabit the high seas, the latter (to which belongs the herring of the Baltic) the shallow waters of the coast. The herring is generally met with in the free open water not far from the surface.

C. Colour.

Hence also its colour is bluish-green, like that of the sea, whilst its scales display the silvery glitter of the sunlit waves. (Protective colouring. Compare, on the other hand, the colour of bottom fish and of predaceous fish which lie in hiding among water-plants, *e.g.*, pike and perch.)

D. Food.

In the open water the herring finds its food, which consists chiefly of all kinds of small free-swimming animals (the so-called Plankton, or floating fauna). It feeds more especially on minute crustaceans belonging



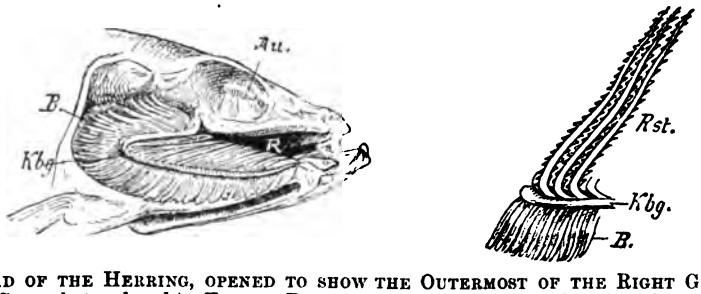
COPEPOD (DIAPTOMUS). A FRESH-WATER SPECIES.
Female with egg-bags attached to the terminal abdominal segment. (Magnified about thirty diameters.)

to the Order Copepoda, or water-fleas, creatures not larger than from one to a few millimetres, but occurring frequently in such enormous quantities as to colour the water red for the space of many square miles, and

Digitized by Google

converting it into a regular broth. (Thsee animals also occur in fresh water in extraordinary quantities, and may be easily caught by means of a gauze net.)

(*a*) These creatures are so minute (it requires 60,000 to fill a herring's stomach) that we cannot conceive a herring catching and swallowing them singly one by one. They are, in fact, taken in large quantities by the aid of the "gill-rakers." The bony rods of these organs are set very close, and are of considerable length, and being,



HEAD OF THE HERRING, OPENED TO SHOW THE OUTERMOST OF THE RIGHT GILLS. (Somewhat reduced.) TO THE RIGHT, PART OF A GILL. (Slightly enlarged.) Kbg., gill-arch; B., branchial lamellæ; R., gill-rakers; Rst., three gill-rakers with denticles; Au., eye-socket.

moreover, armed with teeth, they form a very fine net, allowing the water of respiration to pass to the gills, but retaining the small crustaceans taken in with the water (compare with the baleen plates of the whale). Thus the herring both breathes and takes in food simultaneously.

(*b*) Where these crustaceans are most abundant, the herring, too, is naturally met with in greatest quantity; and this, again, occurs in places where there is a rich supply of the food of the small crustaceans. The latter live principally on rod-shaped algæ or diatoms, which are also found in large quantities in fresh water. (This may be seen by placing under the microscope some of the brown slimy scum which forms in the spring on ponds and pools.) They are very minute plants of highly ornamental structure, of which it requires several millions to fill the space of a cubic centimetre. They are developed specially at the season of the melting of snow in the Arctic seas, and are then driven southwards by ocean currents. Where these currents are stemmed—on submarine banks, or where a cold and a warm current meet—these algæ are accordingly found in enormous quantities; and here, too, we meet with the myriads of crustaceans, which in their turn supply the food of the herring. The latter travels to the feeding-grounds in great shoals (*food migrations*). To accomplish distant journeys like this requires considerable rapidity of movement, of which the herring gives

Digitized by Google

evidence by the possession of a *slender elongated body* (compare with pike) and a *large caudal fin*. However, these small crustaceans do not always occur in such large quantities as to turn the sea-water into an alimentary broth, and for this reason alone the capacity of rapid swimming would be indispensable to the herring. (Compare with other creatures which live on animals of small size, *e.g.*, the swallow and most of the song-birds.)

E. Reproduction.

The eggs of the herring, being heavier than the water, sink to the bottom. If they were deposited in the open ocean or in deep water, they would sink into the fine mud which everywhere forms the bottom of the deep sea. Here, however, there is a dearth of warmth and of oxygen (respiration), both of which are present in abundance in the shallow waters along the coast, where, under the influence of sunlight, an abundant plant life is developed (seaweeds, sea-grass, etc.; plants separate oxygen under the influence of sunlight). *It is to such places that the herring must betake itself to prevent its species from perishing.* The fish for the purpose of spawning associate in enormous numbers, forming gigantic hosts or shoals, which swim towards the coast. The expert fisherman is able to recognise a shoal of herrings even from a distance by the bright reflection in the sky, which is caused by the reflection of the rays of the sun or moon from the silvery coat of the fish. As they swim above their spawning grounds, the fish discharge their eggs, which sink to the bottom, and owing to their albuminous envelope adhere to plants and stones. Having deposited the spawn, the fish which have escaped capture once more turn their course eastwards. The different varieties of herrings (see Section B) spawn at different seasons.

F. Herring Fishery.

It is the migratory shoals which approach the land in order to spawn which are most eagerly awaited by the fishermen. For the purpose of ensnaring the fish gigantic nets are let down vertically into the sea and tied together by their ends so as to form immense walls of meshwork. The meshes of these nets are exactly of a width to allow the head of a full-grown herring to pass through them, but to cause it to be held fast by the gill-covers if it tries to escape backwards. When the nets are full they are lifted out of the water, the herrings are shaken out and conveyed to the coast, where they are prepared (see Section A) for transport.

An enormous number of herrings (estimated at 10,000 millions) are thus caught every year. (The value of the herrings imported into Germany alone from other countries amounts to £2,000,000.) And these numbers, according to the calculations of experts, amount to not

Digitized by Google

more than from 1 to 2 per cent. of the total quantity of the fish. Cod, dog-fishes, whales, seals, and marine birds, annually destroy a vastly larger number than man. What inconceivably vast quantities of the fish must therefore be contained in the sea! (Form a chain from the following links: Diatom, copepod, herring, cod (which see), man. What would happen if the first, or one of the first links in this chain were to perish?)

Allied Species.

The **Sprat** (*C. sprattus*) has nearly the same range as the herring. Its length does not exceed from 4 to 6 inches (see illustration, p. 284). This fish is also caught in large quantities and is put on the market both fresh and smoked. The place of the sprat in the seas of the North is filled in the Mediterranean and the coastal waters of South-Western Europe by the **Sardine** (*C. pilchardus*), which is largely consumed, salted or pickled or preserved in olive-oil. In the same seas we also find the **Anchovy** (*Engraulis encrasicholus*). This fish is preserved in salt or pickled with a large quantity of pepper.

The Common Eel (*Anguilla vulgaris*).

(Length up to 5 feet.)

During the daytime the eel lies hidden in holes in the banks of rivers or ponds, or it buries itself in the sand or mud. Hence its *colour*, like that of all bottom fishes (compare tench and sheat-fish) is dark, and often even quite black. At the approach of dusk it goes in search of *food*, which consists of fish, crustaceans and other small aquatic animals. Occasionally it will also feed on carrion. The body is *snake-like*, and the *tail* flattened and bordered by a fin-band (compare with newt and tadpole of frog). Its progress, which is effected by undulations of the body and strokes of the tail, though not awkward, is nevertheless slow for a predaceous fish. Hence it does not fall on its prey with a sudden rush like the pike, etc., but tries to surprise its victims in their recesses, such as holes in the bank, under roots, etc. By its shape and the suppleness of its slippery body it is well adapted for penetrating into such narrow spaces. The *mouth*, with its wide gape and equipment of teeth, points it out as a carnivorous animal (see pike).

Well known though the eel is itself, its mode of *reproduction* is still in many points unascertained. It is, however, now established that the full-grown eels migrate to the sea usually in autumn, and that the young fish, measuring from 1 to 3 inches, return in spring in innumer-

Digitized by Google

able hosts to the rivers, spread themselves over whole river basins, and there complete their growth. In their course up the rivers these small creatures defy the strongest currents, and even climb up weirs and waterfalls by means of their slimy skin. It is, of course, evident that the eel must spawn in the sea, since the young come out of the sea, and on the coast of Sicily and Italy eggs belonging to fishes of the eel family have been identified. There is reason to believe that these eggs usually remain at considerable depths. It has been now proved that the Leptocephali, small fish of the shape of a ribbon, and of glassy transparency, are the larvæ of different species of the eel family, and one of them, *L. brevirostris*, is believed to be the larva of the common eel. The eel on account of its rich, delicate *flesh* forms one of our most important food fishes.

Sub-Order 2: Fishes in which the Air-bladder is closed (*Physoclysti*).

The Perch (*Perca fluviatilis*).

(Length up to 16 inches.)

The perch is found in all clear fresh waters. Like the pike (which see), it is of *predaceous* habits, and accordingly a rapid *swimmer* (body laterally compressed). For the same reason the mouth has a wide gape, and is very distensible and armed with teeth. The *pharyngeal bones* are also armed with teeth, the *pharynx wide*, the *œsophagus* dilatable, and the intestine short. Like the pike, it lies in wait for its prey amongst water-plants or under the roots of trees growing along the banks, and hence also its scaly covering reflects the tints of the plant-grown spots which it frequents (greenish with dark transverse bands, under side lighter coloured; see carp). The perch is also able to assimilate its colour in a few days to that of the ground over which it swims. (Put a perch into a dark and afterwards into a light tinted vessel, and observe the change of colour. This change is still more striking in the case of the **Minnow** [*Leuciscus phoxinus*].) The only formidable enemies of the perch besides man are the otter, the sea-eagle and the heron. The larger kinds of predaceous fish do not venture to attack it, for the perch can inflict severe wounds with the sharp spines of the *first dorsal fin*—it belongs to the group of spiny-finned fishes (Acanthopteri)—as well as with its *gill-covers*, which terminate in sharp points posteriorly, and are armed with spines and teeth in front. The eggs of the perch are about the size of poppy-seeds, each contained in a thick envelope,

Digitized by Google

the surface of which is glutinous, so that the eggs adhere together in strings or loose clumps, and these are attached generally to reeds or water-weeds.

The **Perch-Pike** (*Lucioperca sandra*), a nearly-related species, resembles the perch in habits. It inhabits rivers and lakes with stony banks in Central and Eastern Europe, but does not occur in Britain. Its colour is usually a dirty grey, the upper side being marked with dark spots and stripes, especially in the young fish, which are still in need of protection (compare with pike and perch). It is of slender, elongated shape, intermediate between the pike and perch (whence its name), and a swift and nimble swimmer. The mouth is adapted for a predatory life, being armed with fang-like teeth (see pike). It attains to a length of about 4 feet, and its flesh is much esteemed.

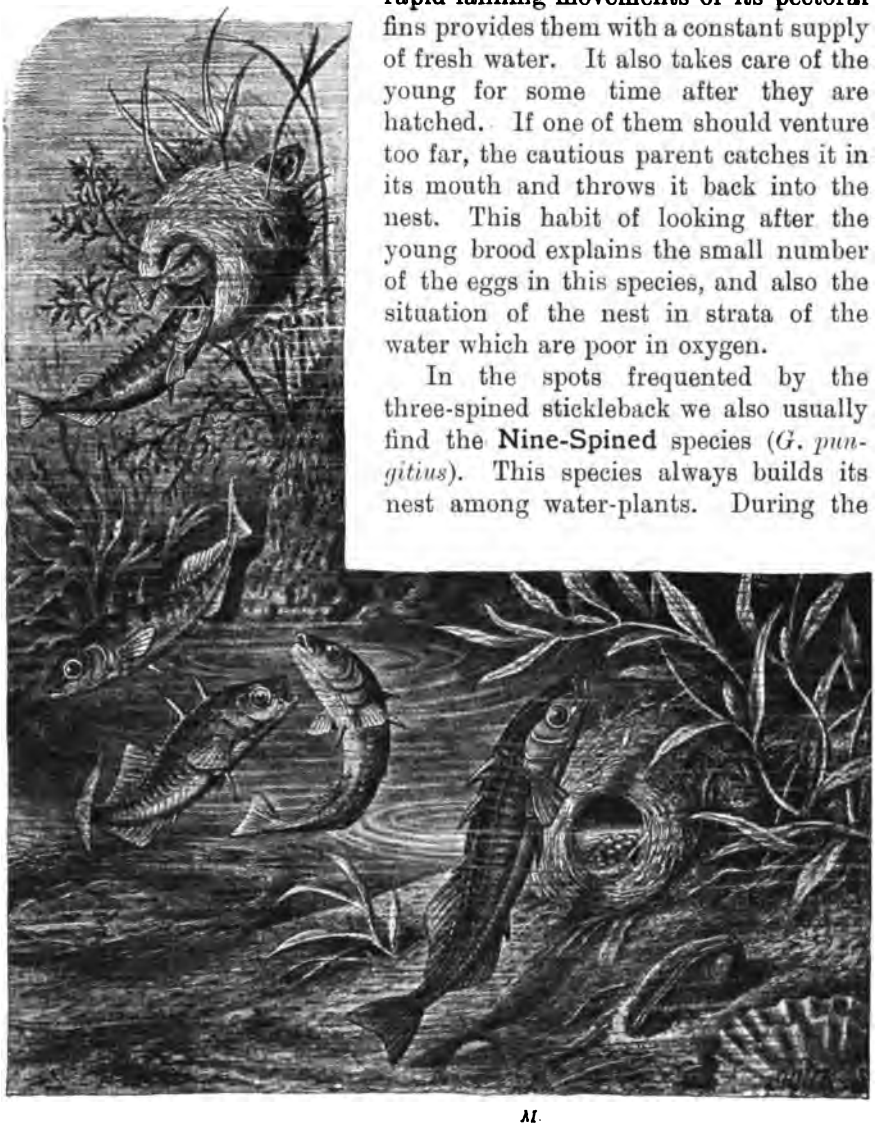
Stickleback (*Gastrosteus*).

The **Common** or **Three-Spined Stickleback** (*G. aculeatus*) is a well-known inhabitant of pools, ponds, ditches, as well as of lakes and marine inlets, in the northern portions of the Old and New World. It is frequently found in very large numbers, and is a pretty little fish, ranging from 1½ to 3½ inches in length. Its slender shape indicates that it swims nimbly; it feeds on young fishes, insect larvæ, etc. The male at the spawning season exchanges its silvery colour for a more handsome "wedding-dress" (compare with birds). The back now assumes a vivid green colour, the under side a brilliant red. The body is protected by bony scutes instead of scales. The ventral fin only consists of one hard spine and one soft ray, while three similar spines are found in front of the dorsal fin. These are erected with lightning-like rapidity at the approach of danger, and maintained for hours long in their upright position. Since, however, the muscles by which these spines are raised would soon become fatigued, a special catch mechanism is provided for keeping the spines in their erect position. By pressing the tip of the spine we fail to fold it down; this, however, is easily effected by pressing with a needle a particular spot at the base of the spine, by which means the catch mechanism is released. On account of these adjustable spines (compare with perch) the little fish has few enemies, and therefore is often very abundant. At the beginning of the spawning season the male constructs a *nest* of about the size of a walnut at the bottom of the water out of roots and water-plants, and then compels first one of the females to deposit its eggs (two or three) in it, afterwards a second female, and so on, until a sufficient number of eggs have been accumulated. The male now takes up its place close in front of the

Digitized by Google

opening of the nest. Here it watches the eggs with great care, and by rapid fanning movements of its pectoral fins provides them with a constant supply of fresh water. It also takes care of the young for some time after they are hatched. If one of them should venture too far, the cautious parent catches it in its mouth and throws it back into the nest. This habit of looking after the young brood explains the small number of the eggs in this species, and also the situation of the nest in strata of the water which are poor in oxygen.

In the spots frequented by the three-spined stickleback we also usually find the **Nine-Spined** species (*G. pungitius*). This species always builds its nest among water-plants. During the



M.

THREE-SPINED AND NINE-SPINED STICKLEBACK. (Slightly less than natural size.)
M., Male, W., female, of the three-spined species; gSt., nine-spined stickleback.

spawning season the abdomen of the male is always of a velvety-black colour.

Digitized by Google

Tunny and Flying-Fish.

The **Tunny** (*Thynnus thynnus*) is to the coast-dwellers of the Mediterranean what the cod is to the inhabitants of the North Sea (which see). It reaches a length of about 13 feet, and a weight of several hundred pounds. The upper side is of bluish-green colour, the under surface grey with silvery spots. On the tapering tail several supplementary fins are found between the second dorsal and the anal fins on the one side, and the crescent-shaped caudal fin on the other. In the spring the tunny approaches the coast in enormous shoals for the purpose of spawning (see herring). It is caught in different ways in different localities: in some places with hooks or harpoons, in others in seines or set-nets. The fishery is specially productive on the coasts of Sicily and Sardinia. Here large stationary nets forming several compartments are arranged and moored in the shallow water along the coast, and into these the fish can enter, but cannot escape. When a sufficient number of fish have been trapped in the last compartment, known as the "death chamber," a terrible slaughter of the captives is commenced. The flesh is not eaten fresh, but is dried or salted. It spoils, however, very easily, and is then very poisonous.

Among the numerous species of fish which are able temporarily to leave their native element, the water, the best known is the **Flying-Fish** (*Exocœtus evolans*). In appearance it resembles a herring, but the pectoral fins are of great size and have the form of wings. When pursued by one of its numerous enemies, it leaps with great force out of the water, and, using its fins like a parachute, soars for stretches of about 600 feet over the waves. It inhabits the seas of the warm and temperate zones.

The Common Plaice (*Pleuronectes platessa*).

(Length from 12 to 30 inches.)

The adult plaice is a vertebrate animal with a strongly asymmetrical body. This deviation from the normal shape (see Part I., pp. 1, 2) becomes, however, explicable from a closer study of its mode of life as a *bottom fish*. The young plaice have a symmetrical shape exactly like other fish; they swim in the same manner, and have both sides of the body of the same colour. As they grow larger the body increases vertically in height, and the fish more and more frequently and for longer periods lie on their left side, which the full-grown fish turns towards the sea-bottom throughout the rest of its life. In this position, however, the left *eye* of the fish would be useless for sight, which would be

Digitized by Google

a great disadvantage to the animal. Consequently this eye is gradually shifted round over the forehead to the right side. The *colour* of the under or "blind" side is now no longer of importance to the fish, and accordingly disappears. The upper, "eye-bearing" side, on the other hand, assumes so striking a resemblance to the colour of the sea-bottom that it is difficult to discern a fish at rest. This colour is brown, grey or black, sprinkled with reddish-yellow spots, and resembles muddy or gravelly ground strewn with shells or pebbles. On moving to another locality the plaice in a short time becomes lighter or darker in harmony with the colour of the new ground (see p. 253). In addition to this, the

PLAICE. (The fish in the foreground about one-tenth natural size.)

fish has the peculiar habit of burying itself in the sand or mud, allowing only its head, with the prominent and very movable eyes (importance of this arrangement), to project. The plaice also swims on its side (side-swimmer); but in spite of its very long dorsal and anal fins, which aid in its progression, it is a slowly-moving creature, and accordingly can only prey on the sluggish inhabitants of the sea-bottom. Its *food* consists principally of crustaceans, molluscs and worms, which it seizes with that portion of the *mouth* which is turned towards the bottom. This part of the mouth is accordingly much stronger than the rest, and equipped with sharp *teeth*. The *inferior pharyngeal* bones have the form of broad plates, by means of which the fish can crush the hardest shells

Digitized by Google

of molluscs and the armour of crustaceans (compare with duckbill). The plaice forms one of the principal objects of the fishery in the North Sea and Baltic.

Allied Species.

The **Flounder** (*Pl. flesus*) and the **Sole** (*Solea vulgaris*) are two important "flat fish" species, and are typical "bottom fish," like the plaice, which they resemble in structure and mode of life. The flesh of the sole is specially esteemed.

The **Turbot** (*Rhombus maximus*), on the other hand, goes actively in pursuit of other fish (length from 1 to 3 feet). For this it is excellently adapted by its great locomotive powers and its equipment of teeth. On account of its delicate flesh, it is, next to the sole, the most highly esteemed of all the flat fishes.

The Cod (*Gadus morrhua*).

(Length up to 5 feet.)

A. Its Home.

Of the numerous treasures which the bounteous ocean supplies to man, none is as important as the cod. The fish is to be found in all parts of the Atlantic Ocean from 40° to 75° north latitude, and also in the adjoining inland seas. In the Baltic there is a distinct race of cod. Large numbers are captured off the British coasts, but they bear no comparison with the enormous quantities which are annually caught round the Lofoden Islands, and more especially on the Banks of Newfoundland. Let us imagine ourselves for a moment, therefore, translated to the first-named inhospitable island group, and taking part in the important business of the cod *fishery*.

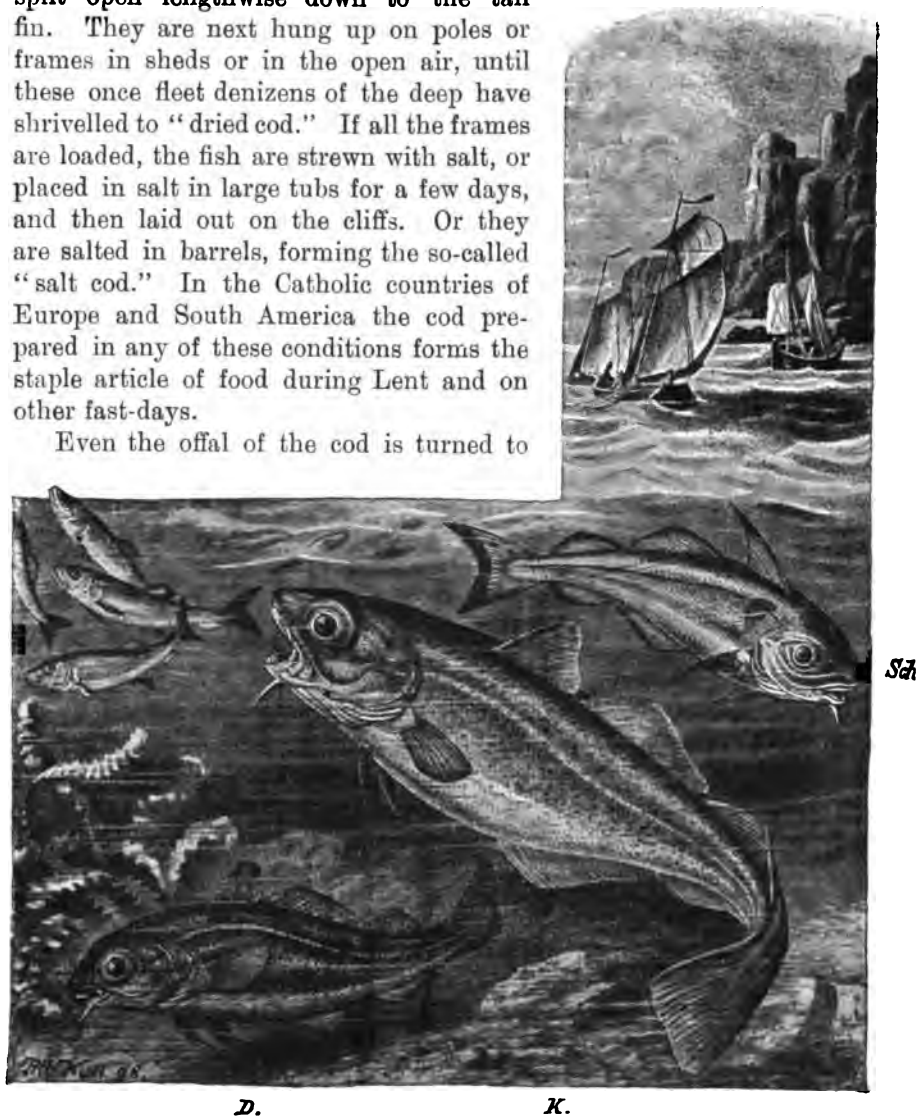
B. Its Capture.

Shortly after Christmas, in the midst of the icy winter and the long Polar night, some 15,000 ships of all the sea-faring nations of Europe assemble around the Lofoden group, and about 70,000 weather-hardened men are busy day and night with the capture and preparation of this one fish. Nets and long ropes to which one or two thousand hooks are attached by short cords are let down into the depths. The bait consists of smaller fish, especially herrings, the entrails of the cod itself, and, in case of need, any object which attracts the fish's attention, and which it swallows with the hook. Many millions of fish are caught in this

Digitized by Google

manner. After being landed on the beach, the fish are gutted, and split open lengthwise down to the tail fin. They are next hung up on poles or frames in sheds or in the open air, until these once fleet denizens of the deep have shrivelled to "dried cod." If all the frames are loaded, the fish are strewn with salt, or placed in salt in large tubs for a few days, and then laid out on the cliffs. Or they are salted in barrels, forming the so-called "salt cod." In the Catholic countries of Europe and South America the cod prepared in any of these conditions forms the staple article of food during Lent and on other fast-days.

Even the offal of the cod is turned to



K., Cod (in Pursuit of Herrings); D., Cod, Smaller Littoral Form; Sch., Haddock. (About one-eighth natural size.)

use. From the liver cod-liver-oil has been prepared for a long time past, and from the heads and entrails a valuable manure, known as "fish guano," is now prepared.

Digitized by Google

With the approach of spring one boat after the other weighs anchor and leaves the Lofoden Islands for home, richly loaded with the treasures of the deep.

Though the spoils thus wrung from the seas of the Lofoden Islands are of immense value, they are inconsiderable as compared with those obtained on the Banks of Newfoundland. Here at the approach of the warm season about 20,000 ships, manned by about 150,000 men, assemble for the cod fishery, the annual takings being valued at about 15,000,000 dollars.

C. Reproduction.

Why do the cod assemble in these waters at definite times and in such immeasurable numbers? Is it for the purpose of spawning in the shallow waters like the herring? Evidently not, since the *eggs* of the cod are lighter than the water, and consequently float near or at the surface. They can therefore be deposited in the open sea (compare, on the other hand, with herring). The reason of these annual assemblies is a different one; the cod, in fact, frequents these localities because they supply it with a superabundance of—

D. Food.

This at the Lofoden Islands consists principally of the herring, and in Newfoundland chiefly of a salmon-like fish, the capelin (*Mallotus villosus*). It is the presence in these places of these fish in large quantities that attracts the cod, their most active pursuer, to the same localities; whilst both the herring and the mallotus resort hither because they find a rich abundance of their own particular food, the small marine crustaceans. The predatory habit of the cod may be seen, as it were, in its face.

(*a*) *It is a large and powerful fish.* Cod-fish taken in the open sea, on an average, weigh about 44 pounds, in exceptional cases even 1 hundredweight. The cod of the Baltic Sea reaches a length of from 16 to 20 inches, and weighs from 4 to 9 pounds.

(*b*) The *elongated body* of the cod sufficiently marks it out as a rapid swimmer. (Compare pike; why is rapid swimming necessary?) The back and sides are generally of a greenish or brown colour, and sprinkled with dark spots. The belly is white. It has three dorsal and two anal fins.

(*c*) The mouth is wide and armed with numerous fine *teeth* (see pike). The lower jaw is furnished with a small tactile filament (barbel; see carp).

Digitized by Google

Allied Species.

The **Haddock** (*G. æglefinus*) resembles the cod in body structure, mode of life and distribution. Its colour is, however, lighter, and it is easily recognised by its sickle-shaped first dorsal fin, the black lateral line, and the dark spot over the pectoral fin. It is placed on the market both fresh and smoked; the flesh has a pleasant flavour, but soon acquires a disagreeable smell. In cooking, the flesh of the cod and haddock can be easily separated in flakes or leaves.

The Sea-Horse (*Hippocampus antiquorum*).

(Length up to 7 inches.)

This peculiar fish lives on the coasts of the Mediterranean and Atlantic ocean. It is rare on British coasts. The fish has its habitat amid the forest of seaweed which lines the coast. Here, resting quietly with its finless *prehensile tail* (compare with chameleon) twisted round the stalk of a piece of seaweed, it is completely hidden from view amid the confused mass of marine vegetation, its *elongated, brown-coloured body*, covered with *scutes*, which project into *spines* and *tubercles*, giving the fish a striking resemblance to a piece of seaweed. By means of a trembling movement of the transparent *dorsal and pectoral fins* it progresses slowly, somewhat after the fashion of a small screw steamer. The head, which bears some likeness to that of a horse (hence its name) is protracted into a long tubular *mouth*, through which the animal sucks up its food (*i.e.*, all kinds of minute animals). The male is provided with a peculiar *brood pouch*, having the form of a bladder-like swelling, and situated on the abdominal surface near the base of the tail. Into this sac the eggs are deposited by the female, and here they undergo their development. The branchial leaflets in this species are not long and narrow, as in most others of the bony fishes, but broad, and resembling a feather or leaf in shape (Lophobranchii = tuft-gilled).

ORDER II.: ENAMEL-SCALED FISHES (GANOIDEI).

Skeleton more or less cartilaginous. The scales or bony dermal plates overlapping and coated with enamel. Opercula present.

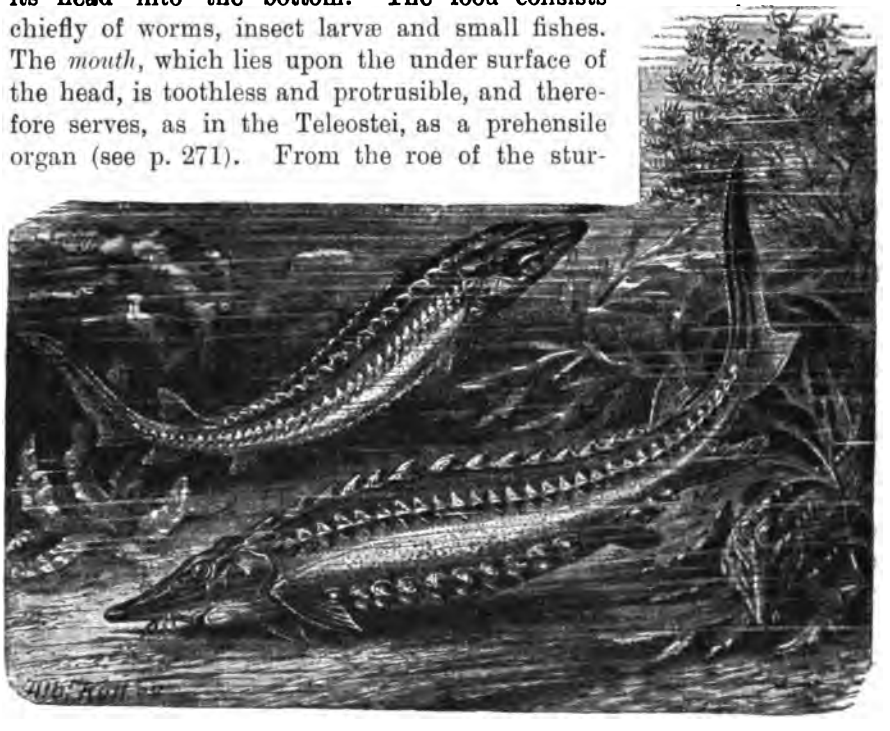
The Sturgeon (*Acipenser sturio*).

(Length up to 18 feet.)

The sturgeon is a *migratory fish*. It inhabits all the European seas with the exception of the Black Sea and Caspian, but in spring travels

Digitized by Google

up the rivers for the purpose of depositing its eggs on shallow sandy spots near their banks (see salmon). The *skeleton* is cartilaginous (see sharks), and receives additional strength from bony plates or scutes developed in the skin. These scutes possess a superficial coating of solid enamel, and are disposed on the top of the head, and in five rows down the elongated body. The *caudal fin* is asymmetrical (heterocercal) as in the sharks. The fish seeks its food in the mud and sand, using its four *barbels* as tactile organs in the search (compare tench and shad), or boring its head into the bottom. The food consists chiefly of worms, insect larvæ and small fishes. The *mouth*, which lies upon the under surface of the head, is toothless and protrusible, and therefore serves, as in the Teleostei, as a prehensile organ (see p. 271). From the roe of the sturgeon and closely related species the delicacy known as caviare is prepared.



STURGEON. (About one-fiftieth natural size.)

The best caviare (Russian or Astrakhan) is prepared more especially from the **Russian Sturgeon** (*A. huso*) which inhabits the Black and Caspian seas and the rivers which discharge themselves into them. This species may attain to a length of 30 feet. From the air-bladders of sturgeons is made isinglass, a word derived from the German *hausenblase* = sturgeon's bladder.

Digitized by Google

ORDER III.: SHARKS AND RAYS (SELACHII).

Skeleton cartilaginous. Opercula absent; branchial apertures opening on to the surface. Mouth usually ventral.

The Blue Shark (*Carcharias glaucus*).

(Length up to 15 feet.)

A. Its Habitat.

This gigantic animal is an inhabitant of tropical and temperate seas. Its northern range extends to the southern coasts of England; hence it is not found in the North Sea. As it frequents the open sea, its *colour* is of a beautiful *slaty blue* above (see herring), whereas the under surface is *white* (see carp). The *scales* are small tooth-like structures consisting of a disc-like root and a spike coated with enamel. Only the spikes of these denticular processes project from the skin, which thereby acquires a granular surface (shagreen). The skin of small sharks is rough, like sand-paper, and is used as a polishing material.

Tooth-like Scale of a Shark.

B. Skeleton.

The skeleton remains cartilaginous throughout life. A skeleton of this nature would be out of the question in the case of a land animal of the gigantic size of this fish (such an animal would collapse under its own weight). It is sufficient in the case of a fish whose body is supported by the water. (See p. 268, and compare what has been said about the size and skeleton of the Greenland whale.)

C. Gills and Eyes.

Gill-covers, like those of teleostean fish, are absent, and the branchial clefts are therefore visible on the neck. The gills lie within the clefts. (For the spiracles of other shark species, see under ray.) The eyes are provided with upper and lower lids and a nictitating membrane.

D. Food.

Like other allied species of shark, the blue shark is of very *voracious and predatory* habits. It is fond of following ships in order to pick up such kitchen offal as is thrown into the sea (hyæna of the ocean).

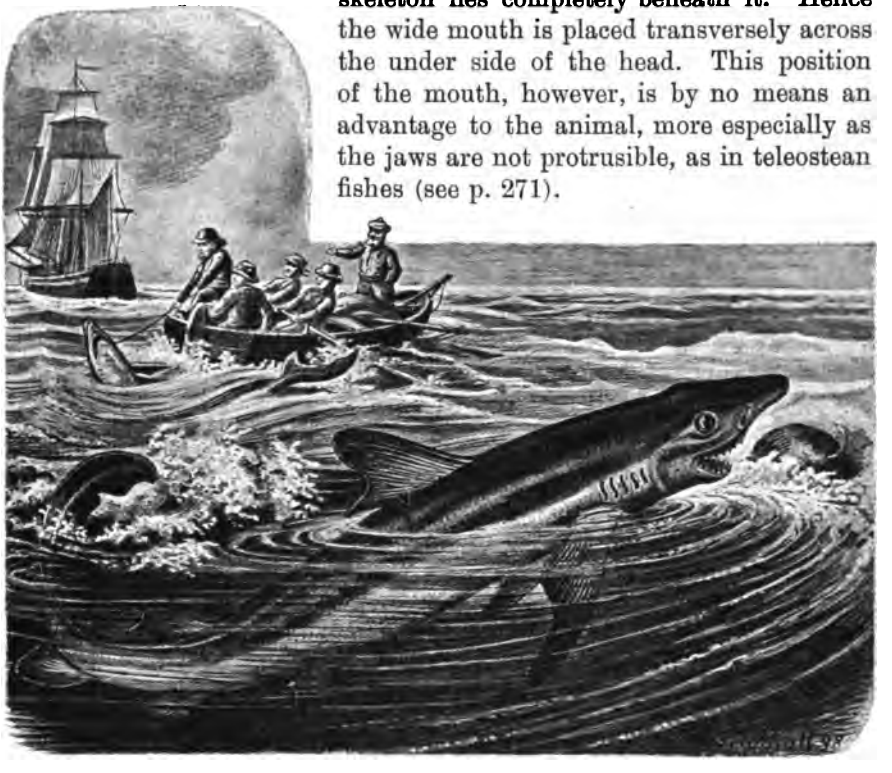
(*a*) Its *size* and *strength* make it formidable to even the largest fishes,

Digitized by Google

and occasionally it will even attack man (man-eating sharks). Its dangerous character in this respect has, however, frequently been much exaggerated.

(*b*) The body is *elongated*, and the tail, with its asymmetrical fin (see pp. 267, 268), extremely powerful. These characters, especially the last named, render the shark, in rapid swimming, a match for any other sea-inhabiting animal. (Describe the other fins.)

(*c*) The cartilaginous cranium projects anteriorly, so that the facial skeleton lies completely beneath it. Hence the wide mouth is placed transversely across the under side of the head. This position of the mouth, however, is by no means an advantage to the animal, more especially as the jaws are not protrusible, as in teleostean fishes (see p. 271).



BLUE SHARK. (About one-fortieth natural size.)

(*d*) This deficiency and the absence of an air-bladder are, however, amply compensated by the remarkable *power of movement* of the animal. On account of the cartilaginous skeleton, the body of the shark is flexible from above downwards, as well as laterally; and, as occasion requires it, the fish rolls itself about its longitudinal axis, or throws itself on its back with equal ease.

(*e*) The mouth bristles with several rows of large, double-edged teeth

Digitized by Google

which are sharp as knives, the edges being in many cases themselves toothed. As a rule, however, the anterior row of teeth only is brought into use at a time. The teeth sit only loosely in the mucous membrane of the mouth, and consequently easily drop out, in which case those of the next row, which hitherto have been lying horizontally in the jaw, with their points directed backwards, are pushed forward and at the same time erected.

(*f*) The *pharynx* and *œsophagus* are very wide; the intestine is short (see pike).

E. Reproduction.

The blue shark brings forth living young. (The majority of the sharks, however, reproduce themselves by means of eggs which are surrounded by a hard, leather-like, usually square-shaped envelope or "purse," so-called "mermaids' purses." The points of these egg-cases are drawn out into long threads, which are used like tendrils for attaching the eggs to water-plants, stones, etc.)

Allied Species.

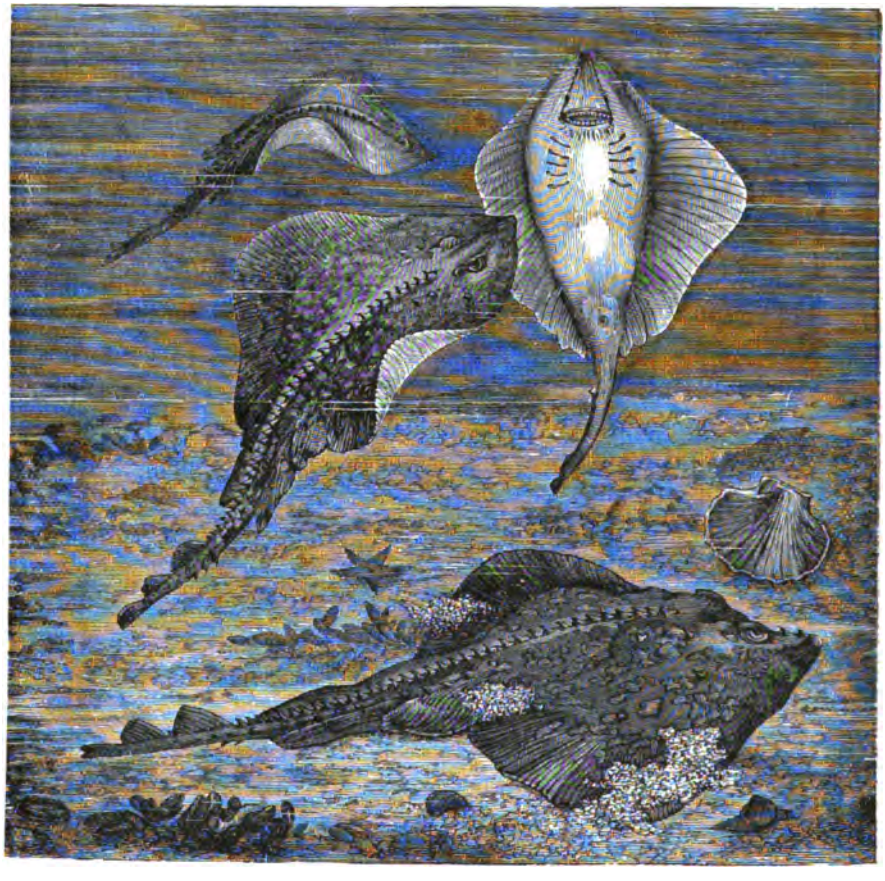
The **Hammer-Headed Sharks** (*Zygœna*) are inhabitants of tropical seas. They take their name from the peculiar, hammer-like shape of their head. They are dangerous animals, which often attain to a length of nearly 14 feet. Several species of shark are also found in the British seas. All these are destructive to the fisheries, but never attack man.

Nearly allied to the sharks are the **Rays** (*Rajæ*). The most familiar species of our seas is the **Thornback Ray** (*Raja clavata*). In their mode of life the rays resemble the flat fishes (see p. 293), although in structure they are utterly different. The head and abdomen are compressed from above downwards into a broad plate, which laterally is fringed by the large fan-shaped pectoral fins, and which carries posteriorly the smaller ventral fins. The thin, whip-like tail with the two dorsal and the small caudal fin is distinctly marked off from the disc-shaped anterior portion of the body. The back of the animal is covered with numerous nail-like spines (hence name), and is exactly of the colour of the sea-bottom on which the animal rests, or lies in wait for prey (fishes, crustaceans, etc.); the under side, on the other hand, is colourless. The transversely placed mouth on the under side of the head and the five similarly placed gill apertures at once distinguish the ray from the flat fishes, and prove its connection with the sharks. The water used for respiratory purposes is not taken in by the mouth, as in teleostean and ganoid fishes, but, as in most sharks (excepting the blue shark

Digitized by Google

and a few other species), by the spiracles, which are situated behind the eyes.

The **Electric Rays** (*Torpedo*), which have the peculiar property of being able to give electric shocks, are inhabitants of the warmer seas. The electricity is generated in an organ which lies between the head and the



THORNBACK RAYS. (One-eighth to one-sixth natural size.)
The spiracles are visible behind the eyes, and in the animal in which the under surface of the body is presented the apertures of the gills are seen.

pectoral fins. It consists of a large number of small cells or chambers, so that it may be compared to an electric battery composed of numerous cells. The shocks serve to defend the fish against enemies and to paralyze its prey.

Another fish possessed of still greater electric powers is the **Electric**

Digitized by Google

Eel (*Gymnotus electricus*), which inhabits the fresh waters of tropical South America. It is closely related to our common eel, and by means of its extremely painful shock can stun even human beings.

The **Saw-Fishes** (*Pristis*) occupy an intermediate position between the sharks and rays. They take their name from a long projection of the snout, each side of which is furnished with a row of sharp teeth, giving it the appearance of a saw. This organ forms a formidable weapon of attack and defence.

ORDER IV.: ROUND-MOUTHED FISHES (CYCLOSTOMI).

Skeleton cartilaginous. The vertebral column is in the form of an unsegmented notochord; segmentation indicated by cartilaginous vertebral arches. Six or seven pairs of sac-like gills; mouth circular; a single (unpaired) olfactory (nasal) pit.

The River-Lamprey (*Petromyzon fluviatilis*).

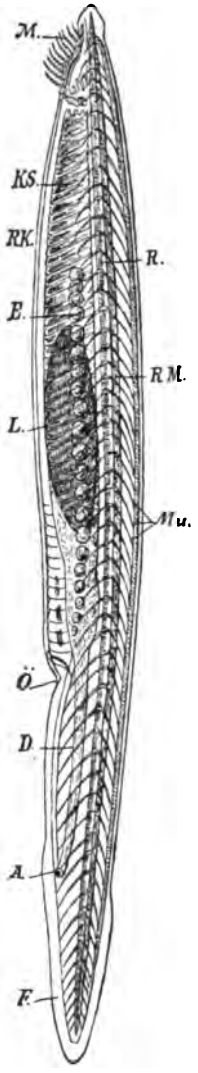
(Length up to 20 inches.)

The lamprey *inhabits* the littoral waters of Europe, North America and Japan. It is a *bottom* fish, and as such has its upper side dark-coloured (olive green to brown). (Compare with tench.) At the spawning season the fish leaves the sea and *migrates* up the rivers in order to deposit its *eggs* in sandy spots near the bank. (The *young*, called ammocœtes, have the form of worm-like larvæ, and only reach the parent stage after several transformations.) In a feeble current the lamprey progresses by undulations of its *eel-like body*, which is furnished with only two dorsal *fins* and a caudal fin (see eel). In a strong current, on the other hand, progress is effected by leaps, the fish propelling itself forwards with a jerk, and attaching itself firmly by means of its peculiarly constructed mouth (suctorial mouth) to a stone or other object. The mouth when open has the form of a circular disc. In its funnel-shaped bottom lies a piston-like organ, the so-called *tongue*. When this organ is retracted, a vacuum is produced in the cavity of the mouth, in virtue of which the animal can attach itself to any object, as firmly as a cupping-glass applied to the human body (compare with

Anterior Portion of Body of the Lamprey (Mouth open).
Z., Tongue; K., the three first gill openings.

Digitized by Google

the suckers of a cuttle-fish). The suctorial mouth, however, is of far more important use in the acquisition of *food* than for locomotive purposes. By means of horny teeth, the lamprey rasps the skin of fishes, and then sucks in the parts it has scraped off, as well as the blood and other body juices. It also consumes carrion in a similar manner. The water required for respiratory purposes can, of course, not be taken in by the mouth when this is attached by suction. It is conveyed to the gills, which are contained in pouches, by seven apertures visible behind the eyes, and is discharged again by the same openings. The animal thus carries on its head nine apertures, viz., the seven branchial openings just mentioned, a single eye, and a median *unpaired olfactory pit* (nose): hence in Germany the fish is known as "nine-eyes" (*Neunauge*). The *skeleton* is cartilaginous, and the vertebral column has the form of an unsegmented rod, which is described as the notochord.



THE LANCELET.
(× 2 diameters.)
E., Eggs; L., Liver; Mu., Muscle-segments. The remaining letters are explained in the text.

The **Sea-Lamprey** (*Petromyzon marinus*) almost completely resembles the fresh-water lamprey in structure and mode of life. This species reaches a length of little more than 3 feet.

ORDER V.: LANCELETS (LEPTOCARDII).

SKELETON consisting only of an unsegmented supporting rod (notochord); no skull or heart.

The Lancelet (*Amphioxus lanceolatus*).

(Length up to 2½ inches.)

This singular little fish is found buried in the sand along the seashore. It represents not only the lowest member of the class of fishes, but also *occupies the lowest stage in the vertebrate division of the animal kingdom.* The body of this animal is colourless and almost transparent, pointed in front and behind, and provided with a membranous fin-like border (F) at the caudal end. The skeleton is represented merely

Digitized by Google

by an unsegmented supporting rod, or *notochord* (R). Neither a *skull* nor a *heart* is developed. The blood, which is colourless, is driven through the body by the larger bloodvessels. There are neither organs of hearing nor eyes, such, at least, as (with few exceptions) we find in all other vertebrates. Light sensations are, however, transmitted by minute organs furnished with cups of black pigment, which are situated in the spinal cord (RM). The olfactory organ is a minute pit. The *mouth* (M) consists of a longitudinal slit surrounded by numerous ciliated filaments, or *cirri*. The water entering the mouth passes into the *branchial sac* (KS), which is perforated by numerous clefts. Through these the water flows into the space (RK) which surrounds the branchial sac, and is discharged from the body by the opening (Ö). The *food* taken in with the water, and consisting of microscopic animals, passes into the *intestine* (D), which terminates in the *anus* (A).

Digitized by Google

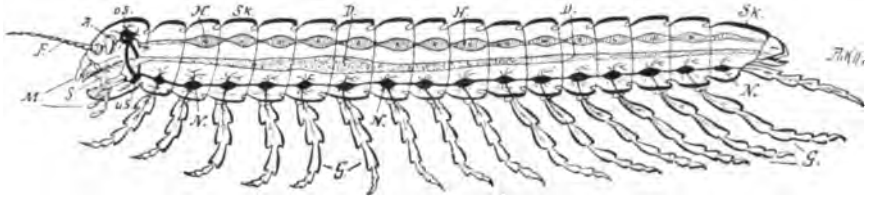
Digitized by Google

PART III.

DIVISION OR TYPE II.: ARTICULATED ANIMALS (ARTHROPODA).

LATERALLY symmetrical animals provided with an external chitinous skeleton. Body composed of a number of annular segments usually coalescing in groups (head, thorax, abdomen). Each segment may be provided with a pair of articulated appendages (limbs). The main portion of the nervous system placed on the ventral side of the body, the heart situated on the dorsal side.

The *laterally symmetrical type of structure* with which we became acquainted in the case of the Vertebrata (see Part I., p. 2) is repeated in insects, spiders, myriapods and crustaceans, which together form the



DIAGRAMMATIC REPRESENTATION OF THE STRUCTURE OF AN ARTHROPOD.

Sk., Chitinous skeleton; G., limbs; N., nervous system; uS., oS., inferior and superior œsophageal ganglion; S., gullet; D., intestine; H., heart; A., eye; F., antenna; M., mouth parts.

second large division or *type of the animal kingdom*. The animals comprised in this division are, however, constructed on a widely different plan, and therefore represent a quite distinct *animal type*.

1. **Skeleton.**—If we open one of these animals, we never find an internal bony or cartilaginous skeleton, such as in mammals gives support and firmness to the body and attachment to the muscles concerned with locomotion (see Part I., p. 4). We are in fact in this, as in all the remaining animal groups, dealing with *boneless* or *invertebrate* animals.

Digitized by Google

Most of these animals, however, are terrestrial in habit, and therefore obliged to carry the weight of their own body (contrast with aquatic animals); many others must be capable of nimble and rapid movement in order to be able to capture their prey (contrast with parasites); whilst, finally, one whole large division, the insects, are capable of raising their bodies into the air by flight. In all, consequently, the body needs a certain amount of firmness or solidity and the muscles firm points of support. Both of these needs are provided for by the presence of an envelope, sometimes more or less soft (*e.g.*, in spiders), but sometimes very hard (*e.g.*, many insects), which covers all the parts of the body, and which is hence aptly described as a *cuticular skeleton* (see also illustrations on pp. 311, 312). Moreover, in the case of animals, such as nearly the whole host of insects, whose life is passed almost entirely in the air and sunshine, this skeleton further provides protection against desiccation (see Part II., pp. 230, 253); whilst, finally, in all it serves to protect the internal parts of the body. This skeleton is composed of a horny substance called *chitin*, which is very resistant to decay (as may be seen in insect collections), and, being very light, does not seriously increase the body weight.

The animals are thus cased in armour, like the knights of old. This armour, however, must not impede their free movements (why?), and therefore, instead of forming one single rigid mass, must, like knightly armour, consist of separate portions capable of sliding upon each other. These portions are, from their shape, described as rings (segments). (Compare with the articulation of the skeleton in vertebrates and the body integument of most reptiles.) These rings, however, are not completely separated from each other, but are connected by portions of the chitinous skeleton which envelops the whole body. In order that the segments should be movable, it is therefore necessary that these connecting portions should remain soft and pliant (articulating membranes). In this way *joints* are formed (contrast with the joints of vertebrates).

The *internal parts* (muscular and nervous system and respiratory organs) of the body likewise exhibit a segmentation corresponding to that of the external portions (somites). In regard to the coalescence of separate rings into larger body segments, see under the separate classes, and especially p. 311.

2. **Limbs.**—Each body-segment may carry (*e.g.*, in myriapods) on its under surface a pair of movably articulated limbs which may be employed for the most various purposes (examples). Several of the limbs in the adult animal almost always function as locomotor organs or *legs*. However, if the chitinous envelope which envelops the legs (as it does

Digitized by Google

the rest of the body) had the form of a continuous unsegmented rod, the animal would either stride along as if raised on stilts, or be quite unable to raise the body from the ground, like, *e.g.*, the earth-worm. In either case it could only move extremely slowly and awkwardly. This, however, would be out of the question in the case of an animal which usually has to seek food scattered over a vast area (consider, on the other hand, the slow-moving larvæ of lepidopterous insects and the limbless larvæ of flies, etc.). It is therefore imperative that the legs should be capable of moving and raising the body with the greatest ease. Accordingly (like those of mammals) they are *jointed, i.e., their chitinous skeleton is divided into several segments which, like those of the body, are united by thin articular membranes* (see illustration, p. 311). This character distinguishes the animals of this division from all other invertebrates, and they are accordingly denominated *Arthropoda*, or animals with jointed feet, *i.e.*, legs.

The *mouth parts* also, as we may learn from the development of the young in the egg, are nothing more than limbs, which have undergone alteration and have become adapted for the prehension of food. They are closely crowded round the aperture of the mouth, moving horizontally against each other and exhibiting the most varying types of structure, according to the different nature of the food of the animals (see under the separate classes).

The *antennæ* also represent modified limbs. They carry the organs of touch, smell, and partly those of hearing.

The Articulata also differ essentially from the Vertebrata hitherto considered in the structure and disposition of the internal organs. We shall here confine ourselves to mentioning only the most important features.

3. **Nervous System** (see illustrations, pp. 307, 311).—This is always situated on the *ventral side of the body*. It consists of a series of *nervous ganglia*, corresponding in number to the annular body segments, and united by two *nerve threads or cords*, the whole presenting an appearance not unlike a rope ladder. From the ganglia nerve fibres pass off to the different parts of the body. The most anterior of the ganglia, which lies below the œsophagus, is united by two nerve cords, which embrace the alimentary canal, with a similar ganglion placed above the œsophagus (inferior and superior œsophageal ganglia). The latter is usually of considerable size, and sends nerves to the most important of the organs of sense—the eyes and antennæ. It is therefore considered as the seat of the intellectual functions of the animal, and described as the brain.

4. **Circulation.**—In the Arthropoda the *heart*, as a rule, has the form

Digitized by Google

of a simple tube, of varying shape and size (see illustration, p. 308), by which the blood is driven through the body. It always lies above the intestinal canal, on the dorsal side of the body, so that in the transparent larvæ of aquatic insects, in the transparent lower crustaceans (*e.g.*, water-fleas), and in many hairless caterpillars and maggots, its movements may be seen through the body wall. The blood flows through the body slowly, and owing to the simple structure of the heart the arterial and venous blood are mixed. Consequently assimilation proceeds at a low rate, and only small quantities of heat are liberated. This explains why arthropods are animals of *varying body temperature*, whose vital activities are dependent in a high degree on the heat of the sun. (Discuss this more fully; see Part II., p. 229.) Hence arthropods do not, like warm-blooded birds and mammals, require any *special provision* for the *conservation of heat*. (For the course of the circulation through the body see insects and crustaceans.)

5. **Respiration.**—In those Arthropods whose life is exclusively or principally passed in the air, respiration is effected by means of *air-tubes* or *tracheæ* (see insects); in those living chiefly in the water, by means of gills or branchiæ (see crustaceans).

6. **Reproduction.**—By far the larger number of Arthropods are *oviparous*. The young, as a rule, differ in their structure markedly from the parent; they are, in fact, *larvæ* (see Part II., p. 254), and only attain to the form of the parent animals after a more or less prolonged *metamorphosis*.

The chitinous envelope, which covers the whole body, being inelastic and incapable of undergoing enlargement, it follows that the growth and metamorphoses of the animal must be accompanied by repeated *castings of the skin*, or moults (the chitinous skeleton being by turns cast off and renewed).

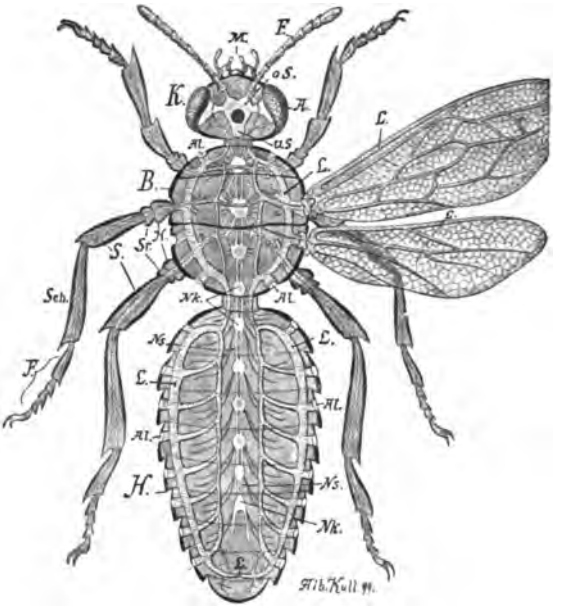
CLASS I.: INSECTS (INSECTA).

ARTICULATE animals breathing by air-tubes (tracheæ); body composed of three distinctly separated divisions (head, thorax and abdomen) with a single pair of antennæ; three pairs of oral appendages, three pairs of legs, and generally two pairs of wings.

1. **Divisions of the Body.**—As in all the Arthropoda (see p. 308), the body of an insect consists of a number of rings or somites placed one behind the other (hence the name insects, *i.e.*, cut or divided). From the following considerations, however, it will appear that these somites cannot all be of uniform shape. The mouth is placed at the

Digitized by Google

anterior termination of the body, and is surrounded by the so-called mouth parts (see Section 3), or oral appendages. These, in order to perform their work effectually, require firm supports, and the muscles by which they are set in motion must have firm points of attachment. Both these conditions are satisfied by the coalescence of several (four) of the somites into a firm capsule, the *head*. The three succeeding somites carry the organs of locomotion, viz., the three pairs of legs on their under surface, and in the majority two pairs of wings attached to the dorsal surface of the last two somites. The same conditions, however, apply to the locomotive organs, especially the wings (compare with the breast of birds), as have been mentioned in the case of the mouth parts; and accordingly these somites likewise, wholly or partially, coalesce into a single division, the *thorax*. (Why have larvæ no special thoracic region?) In the third division of the body, the *abdomen*, the separate rings are quite distinct from each other, neither limbs nor wings being developed in this region.



DIVISIONS OF THE BODY OF AN INSECT, WITH RESPIRATORY AND NERVOUS SYSTEMS (DIAGRAMMATIC).

1. *Divisions of the Body:* K., Head with (A.) eyes; F., antennæ; M., mouth parts; B., thorax (the edges of the separate segments composing it still visible) with the three pairs of legs and two pairs of wings; H., coxa; Sr., trochanter; S., femur; Sch., tibia; F., tarsus with two terminal claws; H., abdomen.
2. *Respiratory System:* L., Tracheæ; Al., stigmata.
3. *Nervous System:* Nk., Nervous ganglia; Ns., nerve cords; uS., inferior œsophageal ganglion; oS., superior œsophageal ganglion, from which nerves pass off to A., the eyes, and F., the antennæ.

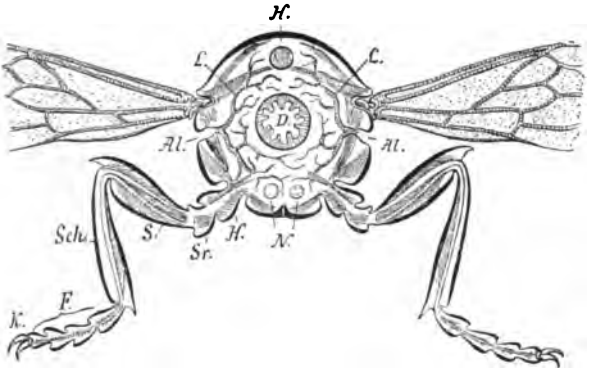
2. **Organs of Locomotion.**—These, as we have seen above, consist of legs and wings.

(*a*) Of the *legs*, three pairs are always present on the lower surface of the thoracic segments. They are thus placed below the centre of gravity of the body, a position by which rapidity and sureness of the animal's movements is secured. The limbs being invariably directed obliquely outwards, the insect, whether standing or running, always rests upon a large surface of

Digitized by Google

support (many inanimate objects, *e.g.*, lamps, tables, etc., are supported in a similar fashion). In running the insect always places three of its legs (two of one and one of the opposite side) upon the ground in the form of a triangle, while the three others are lifted up from the ground. Consequently the animal remains, even whilst moving along the ground, in a condition of stable equilibrium. (Compare with kangaroo and beaver. How far are vertebrates while running in a condition of unstable equilibrium?)

We have already seen (p. 309) why the legs of insects (like those of all arthropods) require to be *jointed*. In the adult insect they consist, as a rule, of five divisions. A short proximal joint, the coxa, connects the leg to the body skeleton, and in conjunction with the second joint, or trochanter, considerably increases the mobility of the leg. The next joint, or *femur*, is always the strongest part of the leg, containing the muscles which move the two following joints, the elongated *tibia* and the *tarsus* or foot, which itself usually consists of several joints. (Why do not these names have the same meaning as in the legs of a mammal, from which they are borrowed?) The structure of the different portions of the leg varies considerably, in accordance with the various modes of locomotion of the insects, and according as the legs subserve additional functions other than those of simple locomotion. In addition to such legs as are adapted for running and climbing (cursorial legs), such as are found in most insects, we further distinguish swimming or natatorial legs (see water-beetle), gressorial legs (see stick insects), saltatorial legs (see grasshoppers), fossorial legs (see mole-cricket), and raptorial legs (see mantis).



DIAGRAMMATIC SECTION THROUGH THE THORAX OF AN INSECT.
H., Heart; D., intestine; N., the two nerve cords; Al., stigmata, with which are connected the tracheæ L. (The shaded portions indicate the muscles which move the wings, legs, and the different divisions of the legs.) H., coxa; Sr., trochanter; S., femur; Sch., tibia; F., foot; K., terminal claws.

(*b*) As has been already mentioned, the second and third thoracic somites each carry a pair of *wings* upon their dorsal surface. They are therefore situated *above* the centre of gravity of the body (just

Digitized by Google

as the legs are *below* it), so that the flying insect is always in a condition of stable equilibrium, exactly as we have seen to be the case in the flying bird (see Part II., p. 142, Section 3. Why, however, are not the wings of birds and of insects homologous structures?). The wings in the different orders (which see) are constructed in widely different ways, but the following may be said as to their structure in general: They are cutaneous structures, stretched and supported by firmer tubes known as "nervures" (compare with the organs of flight in bats). The firmest of these nervures are found upon the anterior margin of the wings, since this requires to be specially strong for cutting through the air (see also Section 2, *c*). The nervures are chitinous tubes containing branches of the tracheæ (see Section 4) and nerves, as well as blood, which latter must be conveyed to all parts of the body for the purpose of assimilation. The muscles connected with flight (alary muscles) are not situated in the wings themselves, since they would load them too much, but in the thorax, and are attached to the extremities of the wings which project into the thorax (compare with the thoracic muscles of birds). The thorax also contains the muscles which move the legs, and thus, in fact, forms a box of muscles.

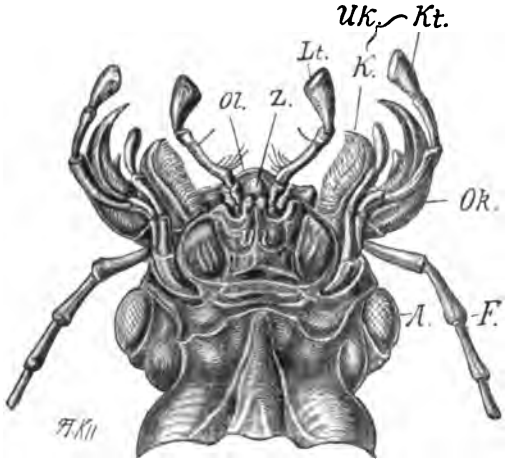
(*c*) *The Flight of Insects.*—In flying, all insects strike their wings obliquely downwards and backwards, and then raise them obliquely forwards and upwards, so that the tips of the wings describe something like the figure of an 8. In the downward stroke the wings must assume exactly the same position as we have noticed in the bird's wing during the downward stroke (see Part II., p. 150, Section *c*); *i.e.*, the posterior section of the wing, being traversed by fewer nervures than the anterior margin, is impelled by the pressure of air originated by the stroke obliquely upwards, so that the upper surface of the wing is inclined obliquely forwards and downwards. (This position may be distinctly seen if we push the wing of an insect—*e.g.*, a butterfly—downwards. Repeat the experiment also with the "artificial wing" described and figured in Part II., p. 151.) Further, the stroke must be followed by the same effect as was noticed in the case of the bird's wing in the downward stroke; *i.e.*, the insect, in virtue of the force resulting from the resistance of the air, must be lifted up and impelled forwards. If now the wing is once more moved obliquely forwards and upwards, its posterior portion must, in virtue of the air-pressure acting from above, be forced obliquely downwards, so that the upper surface of the wing is inclined obliquely downwards and backwards. The effect of the stroke will be easily understood if we turn the upper illustration in Part II., p. 151 upside down. The insect will in consequence be impelled downwards and forwards.

If the downward stroke proceeds with greater force than the upward

Digitized by Google

stroke, the insect rises; if, on the other hand, the upward stroke is the stronger, it sinks downwards towards the ground. The direction of the flight also depends on the position in which the abdomen is placed (see Part II., p. 151, Section *d*), and the direction in which the stroke of the wing is executed. (If the wing is struck vertically, the animal flies in a straightforward direction; if horizontally, it will rise or fall.) Deviations to right and left are accomplished (primarily) by movements of the abdomen, which acts exactly in the manner of a rudder.

3. **Digestion.**—(*a*) In all insects three pairs of the limbs (see p. 308, Section 2) enter into the service of the nutritive function. The first pair form the unsegmented biting jaws, or *mandibles* (Ok.); they are situated below a plate, the *labium*, or upper lip (Ol.), which represents a prolongation of the anterior portion of the chitinous capsule of the head. Below the mandibles are placed the *maxillæ* (Uk., second pair). They consist of several joints, and carry feeler-like processes, the *maxillary palpi* (Kt.). The most inferiorly placed pair of masticatory limbs, viz., the third, as a rule coalesce (see, however, Libellula) into an apparently single piece, the lower lip, or labium (Ul), and are also furnished with a pair of labial palpi (Lt.). The shape and structure of all these parts vary considerably, according to the different nature of the food in the several insect orders (give examples). The palpi, which are provided with organs of smell and taste, are probably used for the purpose of testing the food.



MOUTH PARTS OF A BEETLE (FROM BELOW).
K., Masticatory portion of the maxilla; Z., middle and anterior segment of the labium, or "lingua"; A., eye; F., antennæ. The other letters are explained in the text.

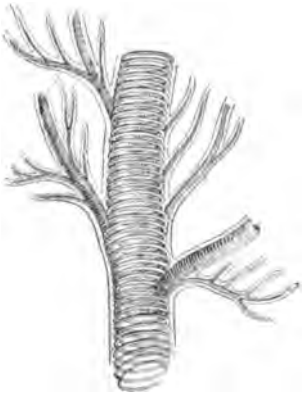
(*b*) As in vertebrates, digestion takes place in the *intestine*, which usually consists of several separate divisions (see, *e.g.*, the honey-bee). Two large salivary glands always open into the mouth.

(*c*) Kidneys are represented by tubular vessels, which are very long, and in many cases very numerous. They are termed *Malpighian vessels*, after Malpighi, a mediæval Italian naturalist.

4. **Respiration.**—(*a*) Insects, living as they do with few exceptions

Digitized by Google

in dry air, cannot (like aquatic animals) breathe by the whole surface of the body or by portions of it (gills of fishes, crustaceans, etc.). Their organs of respiration must be lodged inside of the body, where structures composed of soft membranes are protected against desiccation. These respiratory organs consist of numerous fine tubes, the so-called *air-tubes*, or *tracheæ*. They, as a rule, form two large trunks, which extend along the whole length of the body, and ramify like a tree into finer and finer branches, which penetrate even into the antennæ, legs and wings, and enmesh as in a net all the internal organs of the body. Respiration proper, *i.e.*, the discharge of carbonic acid and reception of oxygen (see Part I., p. 6), takes place in the finest of these ramifications. (In transparent aquatic insect larvæ the tracheæ may be distinctly observed, even under a small magnifying power.) The tracheal tubes take their origin from small apertures of the chitinous skeleton (see illustrations, pp. 311, 312), which are known as *stigmata*. (Show them in a cockchafer or cockroach.)



A Tracheal Tube.
(Strongly magnified.)

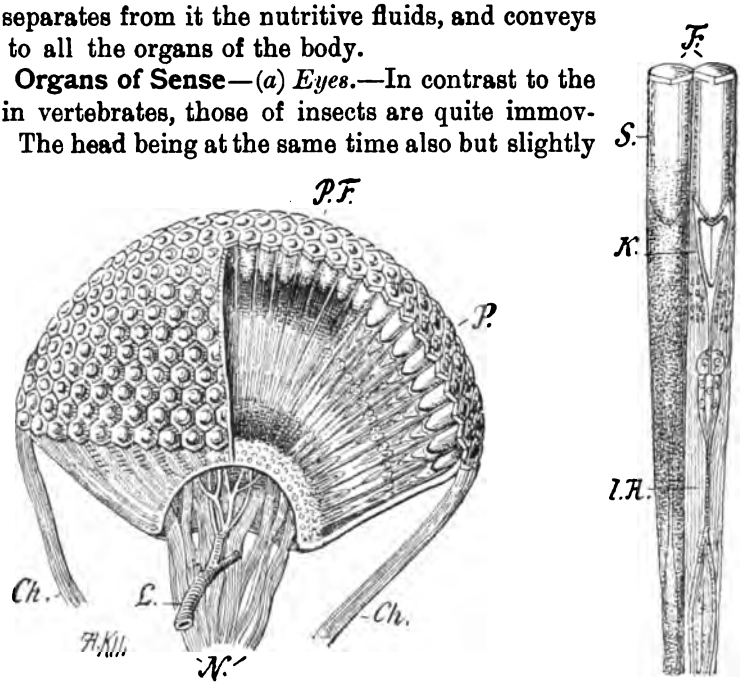
(*b*) The manner in which respiration is effected may be observed in any large insect (especially in a cockchafer which is preparing to fly away). The abdomen is then seen to be alternately contracted and expanded from above downwards. The contraction is effected by muscles, and by the pressure thus exercised upon the tracheal tubes their contained air is expelled through the stigmata. (By putting an insect under water the escaping air may be seen to rise in bubbles to the surface.) With the cessation of the pressure, the tracheal tubes expand once more, their walls being strengthened by a very elastic chitinous fibre (spiral thread) shaped like the steel spring in cushioned furniture. (Compare the cartilaginous rings in the trachea of mammals.) The dilatation of the tracheal tubes in its turn produces a vacuum within them, so that air is again forced into them through the stigmata (compare with a bellows). The movements of the abdomen also explain why the somites of this division cannot, like those of the head and thorax, form a continuous rigid whole.

5. **Circulation.**—Since respiration in insects is not located at special regions of the body (lungs or gills), but takes place over the whole body, these animals do not require bloodvessels for conducting the blood laden with carbonic acid gas to the organs of respiration and returning it to

Digitized by Google

the heart in its pure and oxygenated state. In insects the air, as it were, goes in search of the blood, whereas in other animals the reverse is the case. The muscular heart-tube merely keeps the blood in constant motion. The blood reaches the different organs by interstices and lacunæ between the tissues, and in a similar manner it returns to the heart (see p. 309 and illustration, p. 307). At the same time it bathes the intestine, separates from it the nutritive fluids, and conveys these to all the organs of the body.

6. **Organs of Sense**—(*a*) *Eyes.*—In contrast to the eyes in vertebrates, those of insects are quite immovable. The head being at the same time also but slightly



COMPOUND INSECT EYE (DIAGRAMMATIC).

N., Optic nerve; L., a trachea. Both enter the eye by the sieve-like perforated floor seen below on the right. On the left, and at the outer edge of the right half, the faceted surface is seen, which is continued into the chitinous envelope of the body (Ch.). On the right the eye is laid open in order to show the collection of pyramidal "single eyes," of which it is composed. At P.F. the pyramids are shown surrounded by pigment; at P. without pigment, in order to show the details of their structure. On the right are shown two of the separate pyramids more strongly magnified—that on the left with its surrounding pigment, that on the right without pigment. The letters are explained in the text.

movable, the range of vision would be very limited (what disadvantage to the animal would accrue from this?) if these drawbacks were not counterbalanced by the remarkably large size of the eyes, their strong convexity and entirely different structure. If the eye of an insect is examined through a magnifying lens, its surface is seen to be composed of a large number of small, usually hexagonal or square areas, or *facets*. A thin vertical section through the eye viewed under a strong magnifying

Digitized by Google

power, moreover, shows that this organ is composed of as many elongated pyramid-shaped bodies as there are facets. Each of these pyramids must accordingly be regarded as a single or separate eye, the whole aggregate of which form the faceted or compound eye. The same section will reveal the following further details of structure: The outermost portion of each pyramid is formed of a hexagonal columnar body (S), the outer convex surface of which forms the facet (F). Being of glassy transparency, this portion allows the free entrance of light into the interior of the pyramid. Behind it we find (in most insects) a cone of crystalline transparency (K), which conducts the rays of light to the posterior portion of the single visual element (l.A.). This latter portion is highly sensitive to light impressions, and therefore comparable to the retina of the vertebrate eye. Rays of light, which enter the eye obliquely, and which, by penetrating into adjacent single eyes, would interfere with distinct vision, are absorbed by a pigment which surrounds the crystalline cone, and the lower part of the sensitive (retinal) portion, and are thus rendered ineffectual.

How, then, does an insect see with this peculiar organ? Laborious researches have shown that only a portion of the image of the object seen by the insect is formed in each single visual unit. The adjacent unit sees another part of this image, and so on, so that *the total image in the eye of the insect is composed of a number of separate images, just as a pavement or a picture in mosaic is composed of a number of separate stones.* We can now also understand the great size and convexity of the insect eye: from whatever direction the light rays proceed they will nevertheless penetrate one or other of the numerous single eyes and impress themselves on the animal's consciousness. (We may approach a housefly from whatever direction we please: the insect always notices it, escapes, and is only caught with difficulty.)

In the larvæ the eyes are of much simpler structure, as are also the so-called *accessory eyes*, *ocelli* or *stemmata* (explain these names), which are found on the front portion of the head in some fully-developed insects (*e.g.*, the bee).

(*b*) The *antennæ* vary much in shape (give examples) and, like the legs, are always jointed (why?). They discharge the functions of tactile organs (hence also called "feelers"), but also—as has been shown by numerous experiments—act as organs of smell, and, in many species, of hearing (for the auditory organs of the locust see under that species). A large number of insects seem to be completely dumb. (For the palpi see Section 3.)

7. **Metamorphosis.**—The larva (see p. 310) and the perfect insect differ from each other in structure to a greater or less degree, according

Digitized by Google

as they live under the same, or at least similar, or under quite dissimilar conditions of life (see grasshopper and cabbage butterfly). In the latter case a period of quiescence intervenes in the course of the metamorphosis, during which great and important changes take place. In this, the so-called *pupa* stage of its development, the animal is, as a rule, perfectly motionless, and consequently incapable of taking food. During this period the pupa lives upon the stores of material which are accumulated in the body during its larval existence. The metamorphosis in this case is described as *complete*; when no pupa stage is interposed in the course of development it is known as *incomplete* (give examples). When is the larva termed caterpillar, false caterpillar, or maggot? (See cabbage butterfly, sawfly, and bee.)

ORDER I.: SCALE-WINGS (LEPIDOPTERA).

Mouth parts suctorial, forming a spirally coiled-up trunk. All the thoracic somites coalescent. Anterior and posterior wings similar, membranous, covered with scales. Metamorphosis complete.

A. Macrolepidoptera.

Sub-Order 1: Butterflies (Rhopalocera).

The Large White Cabbage Butterfly (*Pieris brassica*).

(Breadth 2 to 2¼ inches.*)

A. The Egg.

If we watch the white cabbage butterflies in July and August, when they flutter in greatest abundance about our fields and gardens, we shall probably notice some one or other of these merry insects alighting upon the under surface of a cabbage leaf. The insect in question is a female, which, as we shall be able to convince ourselves in a few minutes, has laid upon the leaf a small cluster of golden yellow eggs. Of these eggs she lays from 200 to 300 gradually. Certainly a very respectable number, and yet by no means excessive when we consider how many of the insect's progeny are destroyed by its numerous enemies, or by the weather, either in the larval, pupal, or butterfly stages (compare with rodents, frog, carp, etc.).

The insect selects the under side of the leaf for its delicate eggs, because there they are protected against rain and the parching effect of the sun's rays, and also hidden from the eyes of birds and ichneumon

* Breadth is reckoned from tip to tip of the expanded front-wings.

Digitized by Google

flies (which see). The *leaf of the cabbage* is selected inasmuch as the leaves of this, and of many different plants of the same family (besides many other cruciferous species), form the food of—

B. The Larva.

The latter escapes from the egg after about a fortnight, feeds incessantly, grows rapidly, and after casting its skin several times (why? see p. 310) develops into the familiar "caterpillar." From these two facts—viz., that the larva lives on the leaves of several plants, and especially of such as are cultivated in large quantities—we may understand the *extraordinary abundance* of the cabbage butterfly. (Follow the development of the insect from the egg to the butterfly.)

1. Cabbage leaves, like all green vegetable substances, do not form a very nourishing food (see Part I., p. 101). Hence the larva must consume a large quantity of it, firstly for the purpose of satisfying its needs, secondly in order to grow rapidly, so as to be mature and ready to enter the pupa stage before the first night frost (which would prove fatal to it) sets in, and lastly for the purpose of laying up within its body a store of reserve material on which the life of the pupa may be sustained during the period of quiescence (compare Part I., p. 66, Section C, 2). These reserve materials are found in the larva in the form of fat. For elaborating large quantities of food the larva requires a wide and long *intestine*.

2. The intestine, not being coiled, renders an elongated, tubular, and *vermiform* body a necessary condition. (This "vermiform" character of the body is more or less pronounced in all insects which pass through a pupa stage.)

3. The larvæ of the cabbage butterfly (like those of all Lepidoptera) are not obliged to go in pursuit of their food, and only rarely have to undertake long migrations. They are accordingly slow and lazy creatures with very short *legs*. (Contrast with those larvæ which lead a predatory life. Why are caterpillars unable to dispense entirely with legs, like maggots? How is their sluggishness of importance to them in the storing up of reserve materials?)

4. The three pairs of thoracic legs would not, however, be sufficient to support the elongated body. (Whilst creeping over a horizontal surface the insect would have to drag the hinder portion of its body after it; in creeping vertically downwards, this part of the body would "tip over"; and in creeping along the under side of leaves or similar objects, or along vertical surfaces on a horizontal or oblique direction, it would hang downwards.) Hence, in addition to the thoracic legs,

Digitized by Google

five other pairs—the so-called *abdominal* or *pro-legs*—are developed. These are, in fact, saccular cutaneous tubercles attached to the third, fourth, fifth, sixth, and last (where they are known as the "claspers") of the abdominal segments. Their lower surfaces, or "soles," are usually bilobed and furnished at the margins with numerous small hooks, by which they are adapted for climbing and holding fast to objects. Larvæ with at most five pairs of pro-legs are called "caterpillars." (Contrast with these the so-called false caterpillars of sawflies.)

5. Since the larva lives on solid food, it possesses *masticatory organs*. The mandibles form powerful masticatory pincers.

6. These pincers require strong muscles to set them in action, and the muscles in their turn must have firm points of attachment. These latter are provided in the chitinous skeleton of the *head*, which accordingly is very hard and firm as compared with the rest of the body-covering.

7. Like the majority of animals living above ground, the larva possesses *eyes*. Six of these are situated on each side of the head, and they are of the form of "simple eyes," *ocelli* or *stemmata* (see p. 317). The *antennæ* are very minute structures.

8. Its *colour* (bluish-green, with black dots and a yellow stripe on the back and on each side) renders the larva hard to distinguish on the bluish-green cabbage leaf, especially when it clings tightly against one of the veins of the leaf. But in spite of this protective colouring the larva is easily discovered by its most dreaded enemy, the ichneumon fly (which see). Birds mostly despise it, probably on account of the green fluid which the insect vomits when touched. Man, however, pursues it with unmitigated zeal for spoiling the fruits of his industry. Anyone who has seen a cabbage field with only the naked ribs of the leaves left standing will at once recognise the *damage* wrought by this insect *pest*. Naturally, the best way of stamping it out would be to kill the butterflies before they deposit their eggs. This, however, is very difficult. But some good may be done by crushing the eggs and young larvæ while they are still crowded together, as well as by industriously picking off the older larvæ and by carefully protecting the pupæ of the ichneumon flies.

C. Pupa.

1. By the time the larva has attained to its full size and laid up a requisite store of food material within its body, it enters upon its pupal condition. By this time, however, the food plants, with few exceptions (*e.g.*, the red cabbage), have been killed off by the winter cold, and are covered with snow and sodden with water. They would in this con-

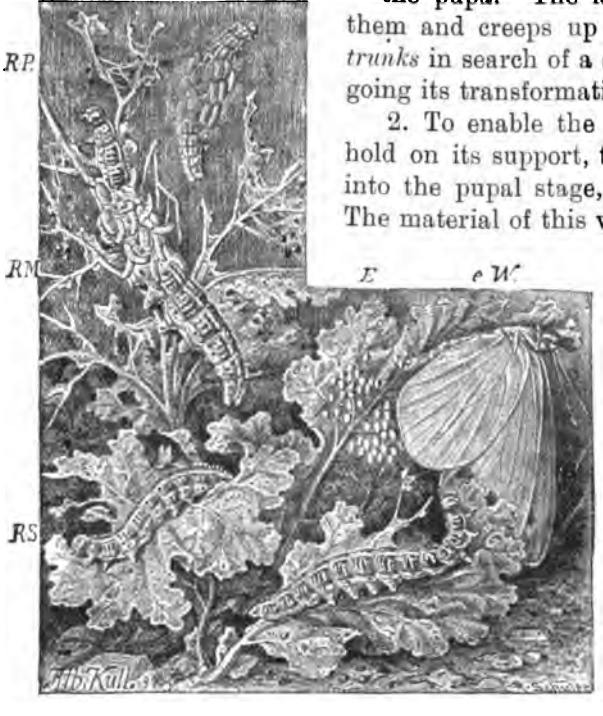
Digitized by Google

IMAGO AND PUPA OF THE LARGE WHITE CABBAGE BUTTERFLY.

f.W., female flying; r.M., male at rest; P., pupa.

dition be utterly unsuitable for sheltering the pupa. The larva therefore abandons them and creeps up *walls*, *planks*, and *tree-trunks* in search of a suitable place for undergoing its transformation.

2. To enable the pupa to maintain a firm hold on its support, the larva, before passing into the pupal stage, fastens itself by a web. The material of this web is secreted from two large glands, and is set free from the labium in the form of a thread, which rapidly hardens. After winding two or three threads over the place it has settled on, the larva bends its head towards the posterior part of its body and draws another thread across its body, which is fastened on the right and left to the supporting surface. This process is repeated until finally a strong belt or band has been spun, which



FEMALE, EGGS AND CATERPILLARS OF THE LARGE WHITE CABBAGE BUTTERFLY.

e.W. Female depositing eggs; E., eggs; R.S., caterpillar, which is being stung by an ichneumon fly; R.M., caterpillar with maggots of ichneumon fly breaking through its body and entering upon the pupa stage; R.P., caterpillar surrounded by the pupæ of the ichneumon fly.

Digitized by Google

has the appearance of a single thread. The skin now splits at the neck, and is stripped off by twistings of the body, leaving the pupa in a suspended condition.

3. *The Pupa.* — This is a greenish-yellow object with black dots and numerous angles and edges, so that, as a rule, it is not very easily remarked. (Nevertheless, the sharp-sighted titmice manage to dispose of a great many of these pupæ.) Portions of the future butterfly may, indeed, be distinguished on the hard envelope of the pupa, but the limbs are never free, as is the case of the pupæ of beetles and hymenopterous insects (which see). The pupa thus remains suspended in an apparently lifeless state throughout the winter. *Life, however, is not extinct in its internal organization*, for there the butterfly is gradually developed.

4. Let us inquire into *the meaning of this pupal sleep*. Very powerful changes must take place in the structure of the pupa in order to convert the sluggish, plant-feeding caterpillar into the swift-winged, honey-sucking butterfly. If the animal, therefore, were active during the pupal stage, a large quantity of the stored-up food material would be used to no purpose (motion, like every other kind of work, being connected with the consumption of material, see Part I., p. 7), and this quantity would therefore be withdrawn from the processes of metamorphosis. (For the same reason we meet with quiescent pupal stages in all insects whose larvæ live under totally different conditions from those of the mature insect, and are accordingly also of an entirely different structure to the latter. Compare, on the other hand, insects with incomplete metamorphosis, *e.g.*, grasshopper.)

D. Butterfly.

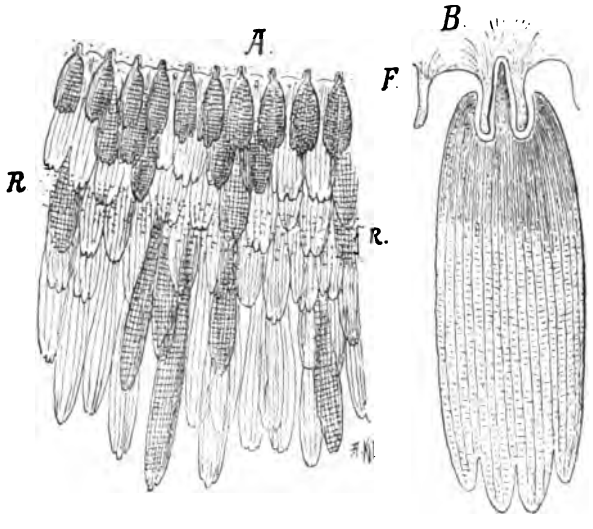
In spring, when Nature has once more returned to life, the now fully-matured butterflies burst through their pupal shroud (a symbol of the resurrection), soar aloft into the balmy air, and feast upon a richly-laden banquet of flowers. These tender creatures live, however, at most but a few weeks, dying, like all other insects, soon after they have provided for the continuation of the species. The cabbage butterflies, therefore, which disport themselves in the air from July to autumn are not the first brood, but their offspring. They have passed through their larval stage, feeding upon all kinds of wild cruciferous plants, and have passed through a pupa stage just like their parents, except that, on account of the high temperature of the summer season, they have quitted the pupal condition as perfect insects in the course of a few weeks. Thus, the cabbage butterfly has two broods (or generations) annually; the second of these, having been developed under vastly more favourable conditions (how so ?), is on that account much more numerous than the first.

Digitized by Google

On account of its short-lived existence, the cabbage butterfly (like all lepidopterous insects) is able to subsist upon a food which is free from nitrogen, *i.e.*, *on sweet vegetable juices*. (There are even insects which in their fully developed condition do not feed on anything at all. What do these live on?) This manner of feeding makes it necessary that the butterfly should be quite different from the sluggish leaf-eating larva.

1. Being a honey-sucking creature, it must be winged like the bee (which see), and accordingly we find two pairs of wings, both functioning as organs of flight.

(*a*) If one of the wings is gently stroked with the finger, it is found to consist of a fine *colourless membrane*, both sides of which are covered by a loose, easily-removable dust. If a piece of the wing be placed under a microscope, this dust will be found to be composed of small regular scales arranged in rows, and overlapping each other like roof-tiles. Each scale is provided at its lower end with a small stalk or peduncle, which is sunk into a pit or depression of the wing membrane.



A., Piece of a Wing of the White Cabbage Butterfly. (Much magnified, to show the Scales.)

R., Margin of wing; the scales covering it are very long. The dark scales are of black colour, the light ones white.

B., A Scale. (More strongly magnified.)

It is fixed by a small peduncle in a depression of the wing membrane (F.).

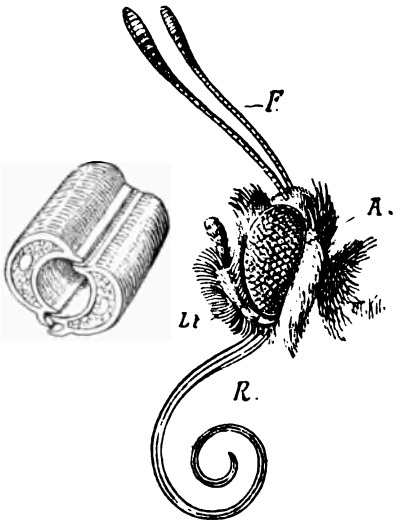
(*b*) The scales impart to the wing its *colour*, which is nearly pure white on the upper surface. The tips of the wings are black, and there are two black spots (absent in the male) on the fore-wings, and a black spot on the hind-wings.

Like a true child of the sun (contrast with crepuscular and nocturnal Lepidoptera), the white cabbage butterfly is clad in a bright-coloured dress, visible from a distance, and rendering the insect conspicuous to members of its own species and easily distinguishable from other species. As long as it is on the wing this dress does not specially endanger the

Digitized by Google

insect's safety, though it renders it more conspicuous than other allied but darker-coloured species; every flying animal, however, by its *motion* alone attracts the notice of its enemies, even though its colours are quite inconspicuous. The capacity for flight, and more especially the *reeling, unsteady, inconstant and incalculable character of this flight*, are to the cabbage butterfly (as to all other diurnal butterflies) a very important means of protection against its enemies. (Enter into this more fully.)

But does not its conspicuous garment betray its presence when it has settled down to rest? might one not expect it really to invite the attention of enemies? That such is nowise the case everyone knows who has found the insect asleep among leaves, and half frozen with the night cold. In this condition the insect *folds its wings together in such a manner that they come to stand vertically erect.* Moreover, since the hind-wings cover the front-wings in such a manner as to leave only the tips of the latter visible, the wings now do not appear half as large as when expanded. Further, on examining the colour of the under side, we shall note the following interesting fact: All that part of the fore-wings which is covered by the hind-wings is (with the exception of the two black spots—see above) pure white; *that portion, on the other hand, which is not so covered is, like the hind-wings, of a dirty greenish-yellow colour*, so that amid the tangled foliage the insect looks like the leaves, and is easily lost to view.



HEAD OF THE WHITE CABBAGE BUTTERFLY (MAGNIFIED), AND ON THE LEFT A PORTION OF THE PROBOSCIS (MORE HIGHLY MAGNIFIED).

F., Antennæ; A., eye; R., proboscis; Lt., labial palpi.

Of course, none of these means of protection are perfect (such, in fact, do not occur in Nature). But by its great fertility (see Section A) the insect speedily fills up the gaps made by foes amidst its ranks. (This also explains why so-called "rare" butterflies, *i.e.*, those whose larvæ are limited to a *single* food plant, or to a few scarce plants, require a more effective protective coloration, since otherwise they would long since have become extinct; see following section.)

2. Several other peculiarities of structure are intimately connected

Digitized by Google

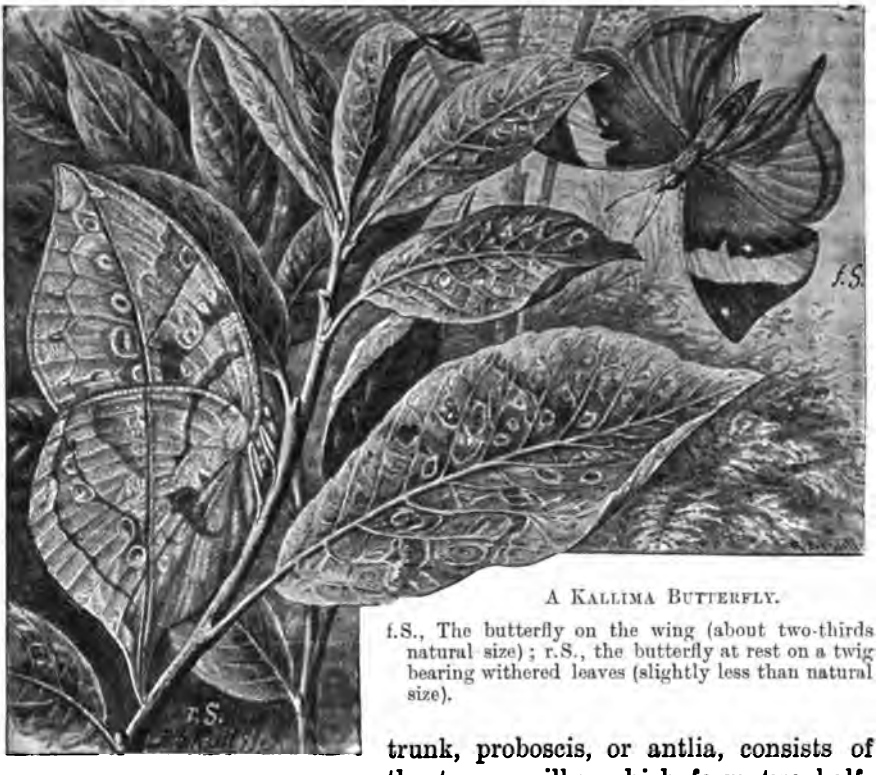
with the flight capacity of this butterfly; thus, like other animals endowed with flight, we find that—

(*a*) It possesses an *elongated* body.

(*b*) All the *thoracic somites* are united as in the nimble-winged bees (which see, and p. 311).

(*c*) The legs are *very weak*; in this way the weight of the body is much lightened, while the limbs are quite sufficient for holding on to objects (motion being effected exclusively by flight).

3. As the food of the cabbage white is of a liquid nature, its *mouth parts* (like those of all Lepidoptera) are *suctorial*. The sucking-tube,



A KALLIMA BUTTERFLY.

f.S., The butterfly on the wing (about two-thirds natural size); r.S., the butterfly at rest on a twig bearing withered leaves (slightly less than natural size).

trunk, proboscis, or antlia, consists of the two maxillæ, which form two half-tubes, and by the apposition of their edges a complete tube. During rest this trunk is spirally coiled up to protect it from injury (spiral trunk or tongue). The other mouth parts usually found in insects (see p. 314) are quite atrophied, as being of no use to a suctorial insect. Only the labial palpi are distinctly visible.

Next to the bees (see honey-bee), the butterflies rank as the most

Digitized by Google

important fertilizers (pollinators) of flowers. By means of their very long proboscis they are enabled to penetrate into very long and narrow tubes, which other insects, having a short proboscis, are unable to probe (see especially Sphingidæ).

4. The insect discovers the source of the honey by means of its large hemispherical *eyes*, and its organs of smell situated in the long thread-like antennæ, which present club-shaped thickenings at their extremities.

Other Butterflies.

All of these, like the white cabbage butterfly, fly during the warm hours of sunshine. All of them, too, in settling down fold their wings vertically. Accordingly, we find that in all of them *the upper side of the wing is decorated with brilliant colours, while the under surface is invariably of a colour which presents little contrast to the insect's surroundings, and thereby hides it from the sight of its enemies.* To what an extent this "protective colouring" may be developed is seen in the Indian and Sumatran genus Kallima. In this butterfly the upper side of the wing is resplendent in black, orange, iridescent blue and various shades of brown, the whole forming a very beautiful colour pattern. When, however, the insect settles in the bushes the colours disappear as if by magic. With its wings folded together, the butterfly now exactly resembles a faded leaf, the under side of the wing being of a dirty brown colour, while a dark stripe bears a deceptive resemblance to the midrib of the leaf, and a prolongation of the hind-wing represents the leaf-stalk. Moreover, when at rest the insect sits with its body and antennæ hidden between the wings, and thereby by its entire outline still further heightens the resemblance to a leaf.

Though our insects do not supply us with so characteristic an instance of protective colouring, many of our species display this phenomenon, though it is less marked in the **Whites** (*Pieris*) than in other species (see white cabbage butterfly, Section D, 1 *b*). The **Small White** (*P. rapæ*) resembles the large white in all points. It, however, deposits its eggs singly on cruciferous plants and mignonette. The larva is of a dirty green colour, and when sitting on the stalk of mignonette can scarcely be distinguished.

The **Black-Veined White** (*P. cratægi*) has fine, perfectly white wings, the veins, however, being black. In many districts this insect has for many years entirely disappeared. This is, however, by no means to be regretted; for the caterpillars, which hibernate in silky nests or "tents" of their own construction (see the brown-tail moth), are very destructive to fruit-trees. Two other well-known species of Whites are

Digitized by Google

the **Pale Clouded Yellow** (*Colias hyale*) and the **Brimstone** (*Gonepteryx rhamni*), in which the wings are of a light yellow (male) or greenish-white (female). Compared with these, the **Swallowtail Butterfly** (*Papilio machaon*) is of very variegated colours. Although abundant on the Continent, it is rare now in England.

On stinging-nettles may be observed frequently black caterpillars with white dots, which are beset with numerous spiny hairs; the protective significance of these structures is sufficiently borne out by the fact that caterpillars provided with spines or hairs are despised by all birds, with the exception of the cuckoo (which see). When the period of transformation to the pupa stage arrives, the larva spins several threads, by which it fixes the posterior end of its body, so that the head hangs downward. The pupa also remains suspended in this position, being attached to the silky web by two fine hooks developed at the posterior end. At the proper time there escapes from it a very handsome butterfly, which has been called the **Peacock** (*Vanessa io*), from the beautiful eye-like marks, composed of a variety of colours on a brown ground, which ornament the wings. The under side of the wings, however, is of very inconspicuous colouring (dirty brown with darker dentated lines); hence, when sitting on the trunk of a tree, the butterfly can scarcely be distinguished from the bark. The same phenomenon is repeated in other closely related species, viz., the **Red Admiral** (*V. atalanta*), the **Camberwell Beauty** (*V. antiopa*), the velvety brown wings of which are ornamented with a row of blue marginal spots and a yellow border, and the **Large** and **Small Tortoiseshell** (*V. polychloros* and *urticæ*), etc.

Anyone who has watched the butterflies known as the **Blues** (*Lycæna*) and the **Dark Green** and **Queen of Spain Fritillaries** (*Argynnis aglaia* and *latonia*) fluttering along roads, forest-glades and heaths, must have noticed with astonishment how these beautiful creatures will suddenly disappear before his eyes as though they had sunk into the ground. One sees the insects settling on a flower to drink in its nectar, or alighting upon the ground to rest, or settling in the grass to sleep, and it is only with the greatest difficulty that one can rediscover them, since not a trace is to be seen of their multicoloured upper sides. The under side of the Blues is grayish-yellow or brownish, sprinkled with white-bordered black dots, while in the Fritillaries the ground colour is pale and sprinkled with numerous spots of silvery or mother-of-pearl-like brilliancy. One might expect these spots would render these insects very conspicuous. But the mere fact that they are only found on those parts of the insects (hind-wings and tips of the fore-wings; see cabbage white) which are visible during rest should cause us to reflect; whilst

Digitized by Google

the fact of the butterfly's sudden disappearance before our very eyes *proves* that we are here concerned with a very effective means of protection. (Describe the various species above mentioned, explain their names, and endeavour to rear them from their larvæ.)

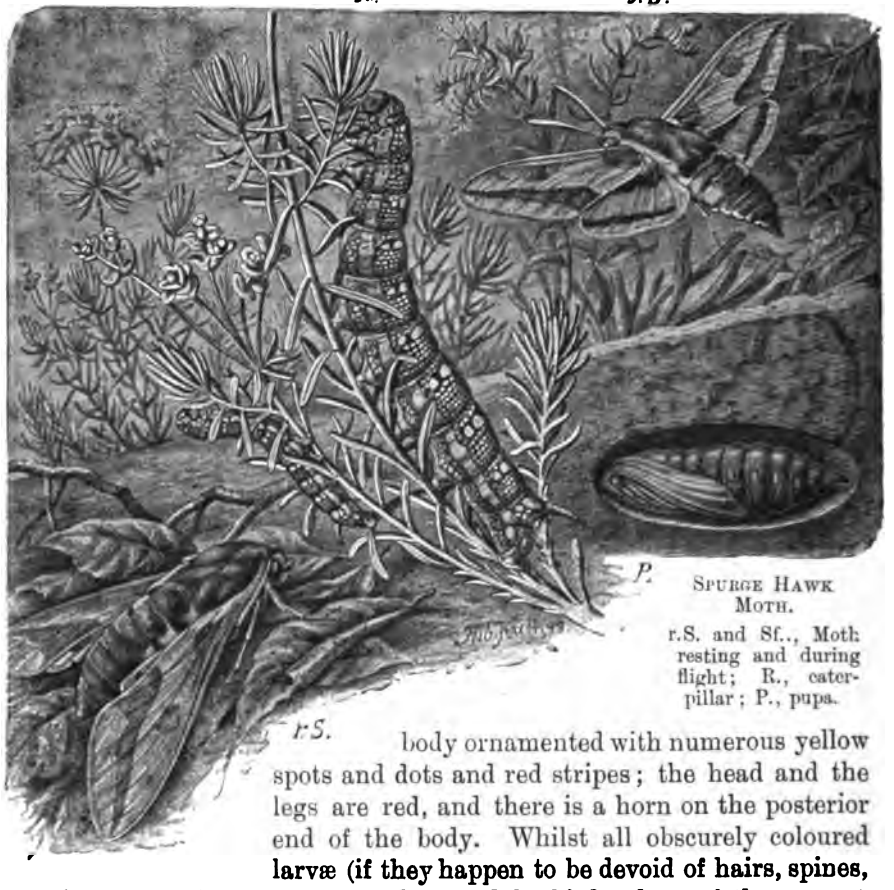
Sub-Order 2: Moths (Heterocera).

Family 1: Hawk Moths (Sphingidæ).

The Spurge Hawk Moth (*Deilephila euphorbiæ*).

(Breadth up to 3 inches.)

The larvæ of this insect, which is very rare in England, are found in autumn on the cypress spurge. They are large, with a greenish-black



Spurge Hawk Moth.
r.S. and Sf., Moth resting and during flight; R., caterpillar; P., pupa.

body ornamented with numerous yellow spots and dots and red stripes; the head and the legs are red, and there is a horn on the posterior end of the body. Whilst all obscurely coloured larvæ (if they happen to be devoid of hairs, spines, or other protective means) are devoured by birds, those of the present

Digitized by Google

species, like all other brightly coloured larvæ, are avoided by them. If a bird happens to peck at one of them, it at once displays its aversion by shaking its head and cleaning its bill. Hence, as in the case of the spotted salamander (which see), the conspicuous colouring serves as a means by which a totally defenceless animal proclaims, as it were, its unfitness for consumption (warning colour). The *pupa* buries itself in the earth after surrounding itself with a loose web.

With approaching dusk the *moth* is roused to activity. Its strong muscular *body* and the long, narrow fore-wings, which are firmly united with the smaller hind-wings by a bristle (compare with honey-bee), render this insect an uncommonly rapid flyer. (Compare with swallow and other swiftly flying birds.) Swift as an arrow the moth cleaves the air; with tremulous wings, like a humming-bird, it soars over the flowers which, by their bright colours and powerful perfume, invite it as a welcome guest to a rich, honey-laden banquet. Its long *proboscis* enables the insect to suck up nectar out of very deep flower-tubes. Its large *eyes* shine in the dark like those of a cat. During the daytime the moth lies hidden from sight on the ground among dry fallen leaves, etc. While at rest the wings are disposed quite differently to those of the diurnal Lepidoptera (see p. 326), the hind-wings being covered by the larger fore-wings, which slope away from the body like a roof. From the way in which the wings are *disposed* we are also able to understand the *coloration* of the insect. The upper surface of the fore-wings and body, which alone is visible during rest, is of such a colour (body olive green, wings of same colour with yellow or reddish-brown blotches) that the moth is not differentiated from its surroundings, and hence only discoverable with great difficulty. The hind-wings, on the other hand, are not visible during rest, and hence their conspicuous colouring (black, pink, brownish-yellow and white) in no way affects the safety of the insect. The same applies to the sides of the body (striped black and white) which, during rest, are rendered invisible by the wings covering them. The under sides of the body and wings, which never become visible, possess neither protective nor ornamental colouring, but are of an indifferent, dirty pink colour. (Compare with the plaice.)

Related Species.

The same distribution of colour is met with in all the related species, *e.g.*, the **Death's-Head Moth** (*Acherontia atropos*). As long as this insect is at rest it is quite inconspicuous (fore-wings blackish-brown, clouded with lighter colour; on the thorax, which is likewise dark-coloured, a peculiar marking resembling a human skull—hence the name).

Digitized by Google

When, however, the wings are unfolded, the black and yellow colour of the hind-wings and of the sides of the abdomen give it a very handsome appearance and render it conspicuous even from afar. The caterpillar, which feeds chiefly on the potato plant, is very gaily coloured (yellow or green with oblique blue stripes on the sides). As, however, is also the case in the caterpillar of the **Privet Hawk Moth** (*Sphinx ligustri*), these colours do not render the creature conspicuous amid its natural surroundings. In the latter insect, the caterpillar is light green with white and violet stripes and red spots on the sides of the body. If this larva be taken up in one hand and a twig of privet be held in the other, the caterpillar appears very conspicuously coloured. Anyone, however, who has ever searched for these insects knows how inconspicuous their garb renders them; for the varied tints of green of the leaves, and the alternations of light and shade, bring about such a change of colour that it is extremely difficult to discover the insects. The hind-wings and sides of the abdomen of the privet hawk-moth are black with red stripes.

The **Pine Hawk Moth** (*Sphinx pinastri*) is exactly of the colour of the bark of pine-trees, on which it is in the habit of resting. Two other well-known Sphingidæ, the **Eyed Hawk Moth** (*Smerinthus ocellatus*) and the **Poplar Hawk Moth** (*Sm. populi*), while resting hold their wings more away from the body, and then bear a striking resemblance to dry leaves. (Observe the metamorphosis of the species mentioned. Explain their names.)

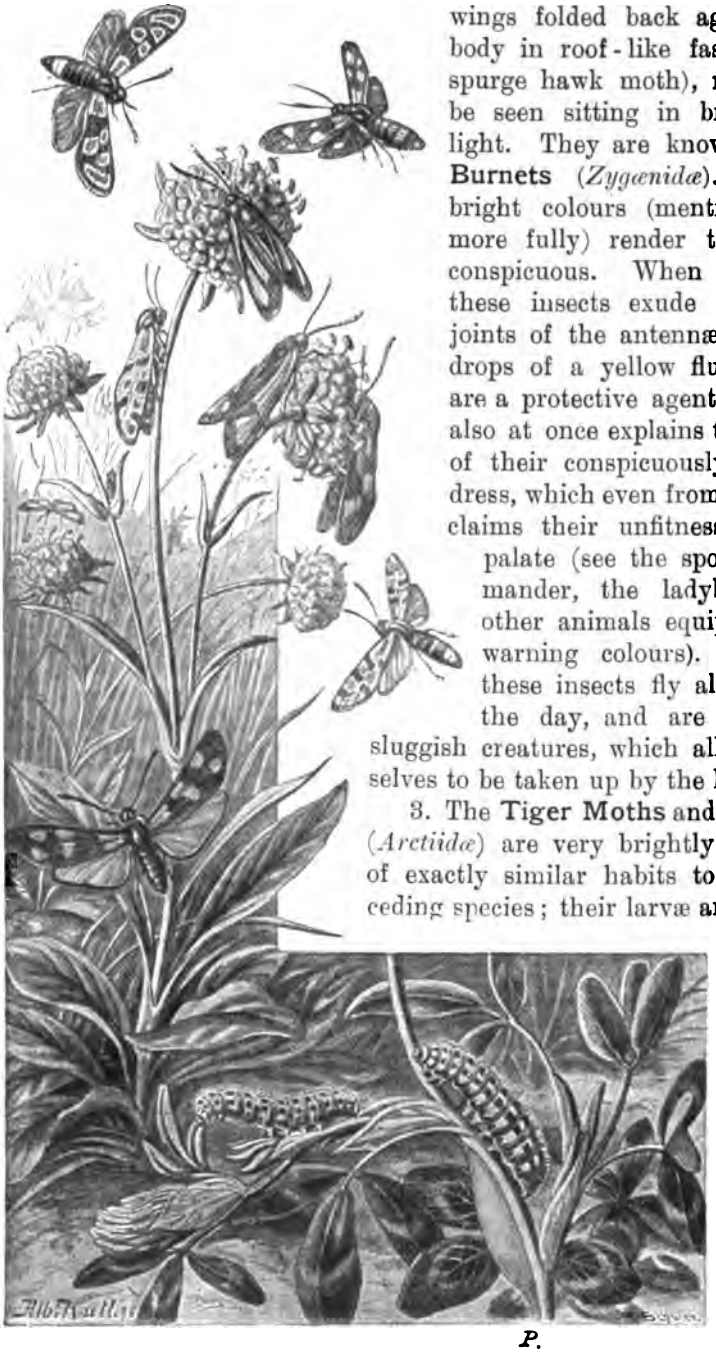
Families 2 to 4: Wood-Borers (Cossidæ); Burnets (Zygænidæ); Tiger-moths (Arctiidæ).

1. The large flesh-coloured caterpillar frequently found in soft-wooded trees (willows, poplars, fruit-trees) is the larva of the **Goat Moth** (*Cossus ligniperda*). Like all wood-boring insects (examples), it possesses powerful masticatory pincers. As it feeds on substances containing but little nutriment, the larva takes two or three years before it is full-grown. The moth is nocturnal, and hence its colours are obscure (grayish-brown with white and black spots and sinuous lines). In the daytime, while resting with wings drawn up against the trunk of a tree, it bears a striking resemblance to the bark or a dead branch.

The larvæ of the **Clearwings** (*Sesiina*) are likewise wood-borers. The wings of the moths are for the most part devoid of scales, and therefore are of glassy transparency. The most familiar species is the **Hornet Clearwing** (*Trochilium apiforme*), which in shape and coloration closely resembles a hornet, and like the latter, too, flies by day.

2. On blossoms, especially those of the scabious, moths, with their

Digitized by Google



VARIOUS SPECIES OF BURNETS.
St., Six-spot Burnet (*Zygæna filipendula*), with two of its caterpillars below, and at P the cocoon of a pupa on a clover-stalk.

wings folded back against the body in roof-like fashion (see spurge hawk moth), may often be seen sitting in broad daylight. They are known as the **Burnets** (*Zygænidæ*). Their bright colours (mention these more fully) render them very conspicuous. When touched these insects exude from the joints of the antennæ and legs drops of a yellow fluid, which are a protective agent, and this also at once explains the reason of their conspicuously-coloured dress, which even from afar proclaims their unfitness for the palate (see the spotted salamander, the ladybird, and other animals equipped with warning colours). Hence, these insects fly also during the day, and are slow and sluggish creatures, which allow themselves to be taken up by the hand.

3. The **Tiger Moths** and **Ermines** (*Arctiidæ*) are very brightly coloured, of exactly similar habits to the preceding species; their larvæ are covered with very long hairs (protection; see the peacock butterfly), and hence often spoken of as "woolly bears."

Digitized by Google

Family 5: Bombycidæ.

The Silkworm Moth (*Bombyx mori*).

(Breadth of moth 1½ inches.)

A. Distribution and Habitat.

With the exception of the honey-bee, the silkworm moth is the only insect which has been domesticated by man. In its native home, India and China, where it is still met with in the wild state, the fine web of its caterpillar has for thousands of years been manufactured into the most costly of materials, silk. From China the culture of the insect spread slowly to the West, but it was not until the year 536 of our era that the eggs of the silkworm were for the first time introduced by monks into Constantinople. On the shores of the Mediterranean the culture of the silkworm gradually became a flourishing industry, inasmuch as the mild climate of those countries is not only specially congenial to the insect, but also to its food plant, the mulberry-tree. In England, owing to its rougher climate, silkworms are kept for amusement but not for profit.

In consequence of culture extending over thousands of years, the silkworm moth has become a very *helpless* creature. (Similar phenomena may be noticed in many other domestic animals; give examples.) It is no longer able to fly, but can only flutter in a downward direction. The young caterpillars no longer seek their food independently, and, like the older ones, often bite through near the stalk the leaves on which they sit, so that they fall to the ground.

As is the case with all other domestic animals, several *races or varieties* of silkworm have been produced by culture.

B. Metamorphosis.

Like all nocturnal Lepidoptera (see goat moth), the silkworm moth is a very inconspicuous insect of yellowish-white colour. On the fore-wings we usually find, in addition, several darker, indistinct transverse stripes. In the natural state the male goes in search of the female, from which—as is the case in all the Bombycidæ—it is distinguished by the large pectinate antennæ, which are the seat of a very fine sense of smell (compare with cockchafer). A few days after leaving the pupal envelope the female lays its eggs, which may number up to 600, after which both it and the male die without having taken any food (the proboscis is rudimentary). During the winter the eggs are preserved in a cool airy spot. (Why?) In the spring, with the breaking forth of the buds of the mulberry-tree, the caterpillars, popularly but erroneously known as "silk-

Digitized by Google

worms," are hatched. They are of grayish-white colour, with a few darker spots on the back and a small horn on the last but one of the abdominal somites. When the caterpillars are full grown they begin to spin a web around themselves amongst brushwood and straw, provided for the purpose by their owners. As the thread emerges from the labium (see white cabbage butterfly) it is glued on to a twig, then to another, and so on, until a loose meshwork is formed, containing the larva in its interior. The insect next twines the threads round itself until they form a dense weft or feltwork, the *cocoon*, in which the *pupa* passes its *quiescent stage*. To an animal living in the natural state this firm and safe dwelling forms an excellent protection against enemies. After two or three weeks the perfected moth casts its pupal skin. Being, like all the Lepidoptera, unprovided with biting jaws, it must use other means for breaking through the pupal envelope. For this purpose it secretes from the mouth a brown acid liquid, which softens and loosens the web, which the moth finally tears by boring and pushing with its head. (The other members of this family construct similar webs, and break them in a like manner.) Hence, in German, moths of this family are called "spinners."

C. Method of Obtaining the Silk.

The silkworm-keeper only allows a certain number of moths, as many as may be required for breeding, to escape from the cocoons. The majority are killed by heat, his object being to obtain the continuous thread of silk, over 3,000 feet in length, which would be torn by the moth if it were allowed to escape. The cocoons are therefore placed in hot water and beaten with birch rods. The heat loosens the cement by which the threads are held together, and the separated threads adhere to the twigs of the birch. A certain number of threads (up to twenty) are next twisted into a single thread and wound off. In this way a long silk thread is obtained, which is manufactured into silk yarn, dress materials, etc.

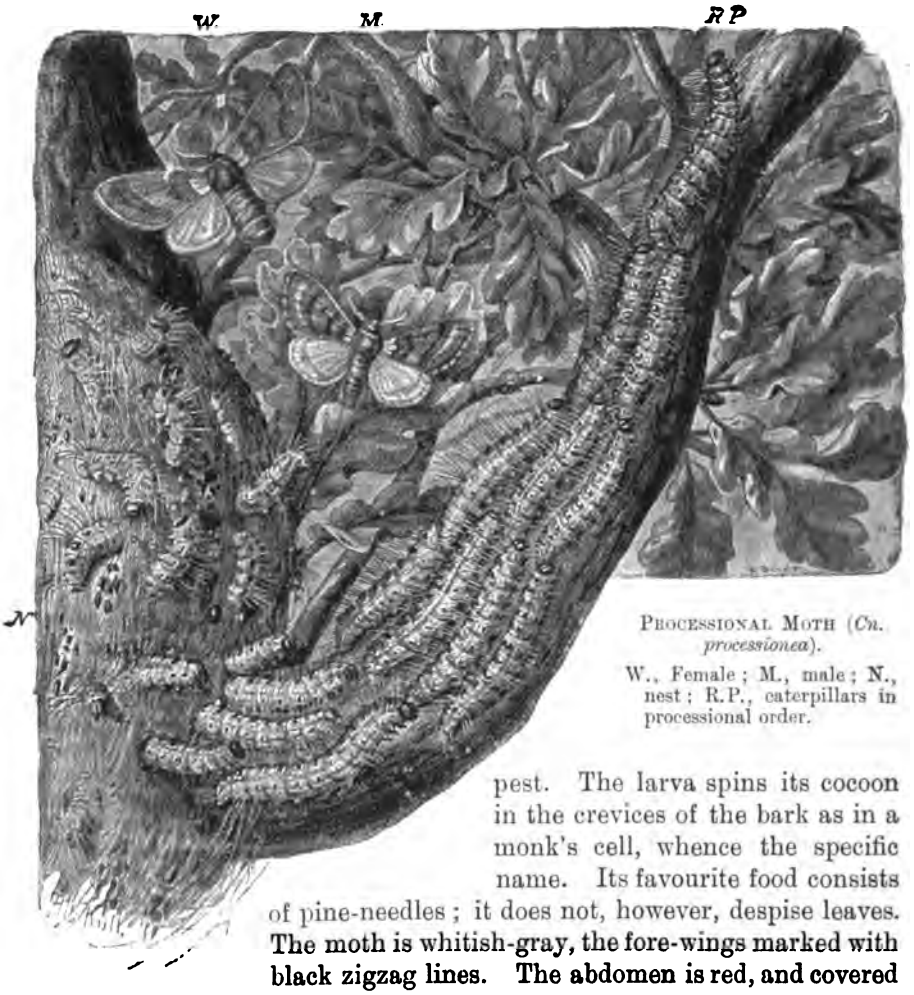
Other Bombycidæ.

Many members of this family are injurious to man. This specially applies to the larva of the **Pine Lappet** (*Gastropacha pini*), which is among the most destructive pests of pine and fir woods on the Continent. One or two specimens have been taken in England, but it is not really a native of the British Isles. The colour of both the caterpillar and moth exactly resembles that of the bark of pine-trees. (The moth, like all the Bombycidæ, rests with its wings depressed.) With the advent of frosty

Digitized by Google

weather the caterpillar creeps under moss for the purpose of hibernating. In spring it reascends the trunks of the pine-trees in order to feast on the pine-needles. It is then that the forester bars its progress by smearing the trees with rings of tar or glue, to which the caterpillars adhere and perish.

The **Black Arsche** (*Ocneria monacha*) is an equally destructive forest



Processional Moth (*Cn. processionea*).

W., Female; M., male; N., nest; R.P., caterpillars in processional order.

pest. The larva spins its cocoon in the crevices of the bark as in a monk's cell, whence the specific name. Its favourite food consists of pine-needles; it does not, however, despise leaves. The moth is whitish-gray, the fore-wings marked with black zigzag lines. The abdomen is red, and covered during rest by the hind-wings.

On the stems of foliage trees on the Continent are frequently observed peculiar structures resembling pieces of sponge. These are the egg-clusters of another moth injurious to trees, called the **Gipsy** (*Ocneria dispar*). This species is almost, if not quite, extinct in Britain. It was

Digitized by Google

formerly common in the fens of Cambridgeshire. (The male is grayish-brown, the female grayish-white; the fore-wings are marked with dark toothed transverse bands.) After depositing the eggs, and while they are still glutinous, the female rubs them over with the end of its abdomen, so that some of the hairs of the latter adhere to them, and to this the spongy appearance is due. The hairy feltwork not only protects the eggs from birds, but also against rain, all of the hairs being directed downwards, so that the water runs down from the egg-cluster as from a roof.

Similar egg-clusters are produced by the **Brown-Tail Moth** (*Porthesia chrysorrhea*). This is a small white moth, with a thick tuft of golden yellow or brown hairs at the extremity of the abdomen (name). The caterpillars, which often do great damage to fruit-trees, emerge from the eggs in autumn. To protect themselves against the winter cold, these delicate creatures fasten some leaves together by their webs, and so form a nest, in which they are proof against cold or storm, rain or snow. Further, to prevent this winter dwelling from falling with the leaves in autumn down to the ground, where they would perish, the caterpillars fasten the stalks of the leaves, among which they are lodged, firmly to the branch.

The caterpillar of the **Lackey** (*Gastropacha neustria*), with its many stripes of diverse colours, is another highly unwelcome visitor on our fruit-trees. The moth is obscurely brown-coloured, and lays its eggs, which resemble the colour of the bark, firmly cemented in a ring around thin branches.

The larvæ of a small brown moth, the so-called **Processional Moth** (*Cnethocampa*), which live on oaks and pines, may prove very dangerous even to man. They are common in many parts of Europe, but are not found in the British Isles. The fine hairs covering their bodies are provided with barbs, easily break off, and permeate the air of the district attacked by these insects; they are very apt to penetrate the skin, producing violent inflammation, especially of the mucous membrane (mouth, lung, and conjunctival membrane of the eye). The caterpillars live in nests, and go in search of food in well-ordered processions (name). The most important enemies of the injurious insects mentioned above are the cuckoo, a predaceous ground-beetle (*Calosoma sycophanta*), and bats, in addition to several singing-birds. (Describe the larvæ and moths of the species mentioned more fully, and try to rear them.)

Digitized by Google

Family 6: Noctuidæ.

The numerous moths belonging to this family are characterized by a thick covering of hairs on the head and the prothorax, which gives them somewhat of an owl-like appearance. All are of crepuscular or nocturnal habits, and therefore obscurely coloured. During the daytime they sit resting, with their wings depressed like the hawk moths (which see), in crevices, against tree-trunks, etc. For this reason we find that in them, as in the former family, the upper side of the fore-wings is protectively coloured. As in the Sphingidæ, too, the only other parts of the body which are ever brightly coloured are the hind-wings on their upper surface.

This distribution of colour is beautifully displayed in the species known as the **Red Underwing** (*Catocala nupta*) and the **Clifden Nonpareil** (*C. fraxini*). These insects, however, are in other respects exceptional members of this family, being active by day as well as by night. The least disturbance causes them to abandon the trunk of the tree against which, while at rest, they nestle so closely that even the trained eye of the collector scarcely succeeds in recognising them. The larvæ are gray, like the bark of willows and poplars, the leaves of which form their food.

All the Noctuidæ are injurious insects. The larva of the **Pine Beauty** (*Panolis piniperda*) frequently outvies the **Pine Lappet** (*Gastropacha pini*) in the destruction of pine and fir woods. A grayish-brown caterpillar, which often makes great havoc among the cabbages by consuming the inmost leaves or hearts of the vegetables, is the larva of the **Cabbage Moth** (*Mamestra brassicæ*). The most familiar of the Noctuidæ is the **Silver Y** (*Plusia gamma*), so called from the silver-coloured mark resembling the letter Y on the fore-wing. The caterpillar of this moth may prove very destructive to all kinds of leguminous vegetables, cabbages, hemp and flax, and other field plants. The larvæ of several other species live in hiding-places or underground (ground caterpillars), and are accordingly of an earthy colour.

Family 7: Loopers (Geometridæ).

The Winter Moth (*Cheimatobia brumata*).

(Breadth of male about 1 inch.)

From the beginning of the colder period of the year down to about Christmas, an obscurely coloured grayish-brown moth is frequently met with in the dusk in gardens and woods. This is the *male* of the winter

Digitized by Google

moth. The female bears little resemblance to the male, or, indeed, to a lepidopterous insect, being possessed only of the merest rudiments of wings, and hence quite incapable of flight. On the other hand, its long legs increase its running powers. The female deposits its *eggs* upon tree-buds, and to get to these is compelled to climb up the tree. The cautious fruit-grower takes advantage of this habit of the insect by smearing his trees with a sticky composition daubed on in rings round the stem and branches, by which the insects are caught before they can do any damage. The caterpillar is green, with a darker median dorsal line, and yellow lines along the sides. It possesses in addition to the claspers

WINTER MOTH. (Natural size.).

On the left: r.M., Male resting; f.M., male flying; W.L., females stuck fast to a ring of gum; e.W., female depositing eggs (eggs are also seen on several other buds). *On the right:* Caterpillars; R.F., a caterpillar letting itself down to the ground by a thread; N., nests constructed from leaves drawn and woven together by the larvæ.

only one pair of abdominal or pro-legs. Thus, in walking, the larva alternately draws up its body into a high arch or loop and again extends it, thus spanning out the path it traverses somewhat in the same way as we should span out a given length with our hand (hence the name "geometers"—land-measurers—applied to this family of moths). During rest the caterpillar usually is only attached by its claspers, and extends its thin body straight away from the branch of the tree. In this position it bears a marked resemblance to a leaf-stalk (protection

Digitized by Google

against enemies. Some other geometer moths exactly resemble dry twigs). In time the larva spins a thread by which it lets itself down to the ground and passes into the pupa stage underground.

Another very familiar geometer is the **Currant Moth** (*Abraxas grossulariata*), also called "the harlequin" on account of its motley dress of black, white and yellow. The caterpillar is similarly coloured, and lives specially on gooseberry and currant bushes (hence name).

B. Microlepidoptera.

The Codlin Moth (*Carpocapsa pomonella*).

(Breadth ½ to ¾ inch.)

The "fruit maggot," which is the cause of apples and pears becoming worm-eaten, is the larva of a small moth which flies in June and July. In the daytime it cannot be seen among the scales of the bark owing to its obscure coloration (fore-wings bluish-gray, with a dark gold-striped spot on the outer surface; hind-wings lustrous brown). In the evening, however, the moth flies abroad and deposits its eggs—a single one on each fruit—on apples and pears. The escaping larva (why is it neither a maggot nor a worm?) eats its way into the fruit, the pips of which form its favourite food. At the time the fruit begins to ripen, the larvæ commence to spin a thread by which they let themselves down to the ground, where they go in search of a suitable domicile—preferably between the scales of the bark—for the winter. The cautious fruit-grower, however, removes these scales and catches the larva as it climbs up the tree, by rings of a sticky composition daubed round the trunks, or under pieces of rags, in which the larvæ are fond of hiding themselves.

In stone fruits we meet with the larva of a closely-related insect, the **Plum Moth** (*Graptolitha funebrana*), and in green peas that of another species, the **Pea Moth** (*G. dorsana*), both of which resemble the codlin moth in their mode of life. The **Grape Moth** (*Conchylis ambiguella*) is a perfect scourge in vineyards. The larva, which is incessantly pursued by the ladybird, destroys the blossoms of vines; in this condition it is known as the hay-worm. It also attacks the berries, which then turn sour, for which reason the larva is now called "sour-worm." The larvæ of many species in this division of Lepidoptera are called rollers, because they roll together the leaves and other portions of plants, in order to hide themselves.

To the Microlepidoptera belongs also the great host of small *moths* called Tineidæ. The most familiar of these is the common **Clothes Moth** (*Tinea pellionella*), the larva of which lives on hairs and wool, out

Digitized by Google

of which it also spins a protecting envelope. The safest means of protecting clothes and upholstery against this destructive insect is by industriously beating them. The "white corn-worm," which often does great damage in granaries, is the larva of the **Corn Moth** (*T. granella*).

ORDER II.: SHEATH-WINGS OR BEETLES (COLEOPTERA).

Mouth parts masticatory; the first thoracic segment (prothorax) free; the fore-wings form covers (elytra) for the hind-wings. Hind-wings membranous and folded together during rest. Metamorphosis complete.

Family 1: The Chafers, or Lamellicorn Beetles (Lamellicornia).

The Cockchafer (*Melolontha vulgaris*).

(Length 1 to 1¼ inches.)

A. The Fully-developed Beetle.

1. *How it emerges from the Soil.* — At the time when the "May-bug" (name) makes its appearance in spring, to the great joy of the children, it has already accomplished a long and arduous portion of its life's journey. As long ago as the August of the preceding year it has cast off its pupal shroud, and, still buried over a foot deep beneath the soil, has developed into the perfect insect (see Section B, 1). When the spring comes round it proceeds to work its way up to the light.

(*a*) For this purpose it slowly burrows upward with its head, which is covered above with a very thick and very prominent *cephalic shield*.

(*b*) The last abdominal somite is prolonged into a strong spiny point, the so-called "anal style," which the insect uses as a means of support against the inequalities of the soil, at the same time pushing itself upward by means of

(*c*) The *middle and posterior pairs* of legs. The terminal spines of the tibiæ of these two legs assist in this operation by maintaining a secure hold in the ground. (Anyone who has held a cockchafer in his closed hand must have noticed the great strength which this animal exerts in burrowing.)

(*d*) In burrowing the beetle employs also the broad shovel-like tibiæ of the first pair of legs as shovelling or scraping implements (fossorial legs; compare with mole and mole-cricket).

(*e*) These instruments require strong muscles to set them in action, and hence the part of the body which includes these muscles, viz., the

Digitized by Google

first thoracic somite (prothorax), is of specially large size. (Contrast with swimming and leaping insects.) Moreover, since the fore-legs must be endowed with considerable mobility, the *prothorax remains free*, instead of coalescing with the other thoracic segments. (This is also the case in all other beetles, as well as in grasshoppers and bugs, constituting the division of so-called "cursorial insects," all of which employ their fore-legs actively in running, climbing, scraping, seizing and mastering their prey, removing obstacles and loads, etc. Contrast with these the "flying" insects: Lepidoptera (butterflies and moths), Hymenoptera (bees and wasps) and Diptera (flies).)

The dorsal portion of the chitinous covering of the first thoracic segment (prothorax) is termed the *pronotum*. In the cockchafer it is black or red, or appears whitish owing to a covering of short hairs. When the wings of the beetles are not spread apart, only a small triangular portion of the second thoracic segment, the so-called *scutellum*, remains visible, being interposed between

(*f*) The wing-cases, or elytra (see Section 2, *a*). These hard covers protect the delicate wing membranes whilst the beetle is working its way upwards through the ground.

2. *Adaptation for Flight.*—Having at last one evening reached the surface of the ground, the cockchafer soars upward into the mild spring air, and flies with a loud humming noise from tree to tree.

(*a*) As is the case in all beetles, only the *hind-wings* are used as organs of flight. The fore-wings have the form of horny plates, brown in colour, their function, as already intimated, being to protect the fine membranous hind-wings against injury. They are for this reason described as *wing-covers*, or elytra. The hind-wings, being longer than the fore-wings, are folded together in order to be completely hidden beneath the latter. When preparing for flight, the cockchafer raises its fore-wings somewhat and begins to breathe energetically, probably for the purpose of laying up a store of air to be used during flight. (There can be no question here about a diminution of the body weight; see Part II., p. 145, note.) In Germany children are accustomed to play with cockchafers, which are very common on the Continent. They sing a rhyme when the insect is "counting"—that is, making the respiratory movements preparatory to flight—just as children in England sing to the ladybird:

> "Ladybird, ladybird, fly away home;
> Your house is on fire, your children at home," etc.

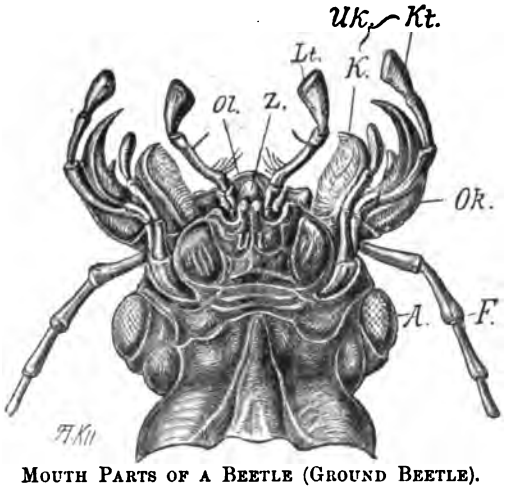
The "spiracles" or stigmata (see p. 315) are situated above the five white triangular spots of the otherwise black abdomen, in the fine

Digitized by Google

membrane which unites the hard ventral with the soft dorsal portions of the abdominal somites.

(*b*) The elytra (note their convex shape) are continued over the *whole dorsal surface of the abdomen* as far as the anal style. Hence, this portion of the abdomen, unlike all the other parts of the body, remains soft and extensile. (Explain the importance of this in respiration.)

(*c*) The body of the cockchafer is stout (see Section 3 *d*), and its centre of gravity lies far behind the point of articulation of the wings. Hence, during flight the beetle assumes an oblique position relatively to the direction of flight, so that it presents a large surface to the air. For this reason the cockchafer is but an *indifferent flyer*. Nor, when we consider the nature of its food, does skill in flying, like that possessed by the bee or butterfly (which see), seem to be specially necessary in the case of this insect.



MOUTH PARTS OF A BEETLE (GROUND BEETLE).

Ol., Labrum; Ok., mandible; Uk., maxilla; K., masticatory portion, Kt., palpus, of the maxilla; Ul., labium; Z., its middle, anterior portion, or tongue (lingua); Lt., labial palpi; A., eye; F., antenna.

3. *Food.* — The food of the cockchafer consists of the leaves of fruit-trees, willows, oaks, beeches, horse-chestnuts and other trees.

(*a*) Its *eyes*, and more especially its *antennæ*, point out to the animal where its food is to be found. The last six (female) or seven (male) joints of the ten-jointed antennæ are widened out into large plates or lamellæ (lamellicorn beetles), forming an elegantly-shaped fan, of which the remaining joints form the handle. The larger number and size of these lamellæ in the male implies an enlarged surface, on which are situated the minute organs of smell. This difference becomes comprehensible when we consider that the male discovers the female by the sense of smell. (In what other insects do we notice the same phenomenon?)

(*b*) Before commencing its meal, the cockchafer secures a firm hold of the leaves by means of the *sharp claws* of the last joints of its toes. In cool weather the beetle becomes rigid, so that the claws cease to act. It may then be easily shaken off the tree, especially in the mornings after cold nights.

Digitized by Google

(*c*) The pincer-shaped *mandibles* cut off successive portions of the leaves, which are then finely crushed by the masticatory parts of the maxillæ and conveyed to the mouth. Hence, the mouth parts of the cockchafer, like those of all beetles, are constructed on the masticatory type.

(*d*) Leaves are poor in nutritive material (see Part I., p. 101, Section 1). Hence, as in all vegetable-eaters, the *intestine* is long and wide, and therefore requires considerable space for its lodgment. Accordingly, the insect is plump and broad (as we find in herbivorous mammals. Contrast with it the carnivorous species among beetles).

B. Development.

1. A few weeks after the beetle has left the earth its end approaches. Previously, however, the female with the aid of its fossorial legs (see Section A, 1 *d*) burrows several holes in the loose soil, in each of which it deposits a number of *eggs*, which are white, and about the size of a hemp-seed. A few weeks later the *larvæ* emerge. At first these grubs feed on tender roots, but later on stouter and firmer ones. With the approach of the cold season they travel downwards to a depth where frost does not penetrate and enter upon a winter sleep (owing to want of food). In the following spring they once more ascend into the upper strata of the soil, where food is abundant, eat their fill, moult (why ?), and feed anew with increased voracity. In this manner they live until the summer of the third year. They then dig a hole and change to the *pupa* condition, in which all the limbs remain free from the body. (See illustration, p. 348, and contrast with pupa of lepidopterous insects.) After only a few weeks passed in the quiescent stage the *perfect beetle* bursts through the pupal skin, and, as we have seen above, comes to the surface in the spring of the fourth year. (In South-Western Germany, Switzerland and France, the cockchafer, on account of the higher temperature of the soil, reaches its full development by the third year.)

If a very large number of cockchafers make their appearance in a particular year, we can reckon on having another "May-bug" year in the fourth (or third) year following. Naturally, this does not always hold good, for the weather may turn out unfavourable to the development of the larva, or some large increase in the enemies of the beetle and its larva may fortunately cancel the calculation.

2. As already seen, the larva of the cockchafer lives upon the roots of plants. *It therefore leads a subterranean existence, and we may naturally expect it to have an entirely different structure from the fully-developed beetle.*

Digitized by Google

(*a*) The grub, in fact, has a *vermiform* shape, resembling both a caterpillar and an earth-worm. Hence, it possesses a form of body equally adapted for the reception of a food poor in nutriment (see white cabbage butterfly) as well as for locomotion in the soil (see earth-worm). From the caterpillar, however, it is distinguished essentially by the absence of abdominal or pro-legs. Indeed, living *in* the soil, which supports it on all sides, the larva does not require these aids to locomotion. The only limbs present are

(*b*) Three pairs of *thoracic legs*, which are long and weak, and consequently not adapted for burrowing and scraping. (What is the shape of fossorial legs?) For these purposes the larva employs

(*c*) The powerful pincer-like *mandibles*. The action of these may be seen by putting a cockchafer grub into a glass vessel containing earth. If the earth is loose the animal scrapes it aside with the outer edge of the mandible; if it is firm, it bites the soil loose bit by bit with these organs. The pieces of soil thus loosened are pushed backwards by the help of the thoracic legs, and also with the head, the animal turning its body round for the purpose. The powerful mandibles are also used for gnawing hard roots, and, as in the case of a caterpillar (see white cabbage butterfly), require

(*d*) Firm supports, which are furnished by the *hard skeleton of the head*. Being used, moreover, as a burrowing instrument, it is necessary that the head should be provided with a hard covering, in contrast to the remaining soft portion of the body.

(*e*) Like most animals living beneath the soil or in the dark (give examples), the larva of the cockchafer is *devoid of eyes* and of *white colour*; only the head and legs are yellow, being more strongly chitinized. The egg and pupa are also white. (Contrast with the developmental stages of insects which live in the light.)

C. Place of the Cockchafer in the Economy of Nature.

Leaves and roots being, as already mentioned, of small nutritious value as a food, it follows that the cockchafer as well as its larva are creatures of *insatiable voracity*, and hence highly *injurious* animals. In so-called "May-bug" years large numbers of fruit and forest trees are frequently despoiled of their entire foliage by these beetles. Still worse is the damage done by the grub, which by gnawing at the root destroys the *whole* plant, and thus ravages extensive fields, meadows and plantations. Unfortunately, there is only one animal, viz., the mole, which can get at these pests in their subterranean retreats. It therefore deserves to be well protected, like the rooks, which pick up large

Digitized by Google

numbers of the grubs turned up by the plough. A still more effectual means of preventing the damage consists in destroying the beetle itself (why?), and also by protecting its enemies, viz., bat, badger and hedgehog, but especially the great host of song-birds. Indeed, as an excellent naturalist has tersely expressed it, "Protection for song-birds means food for men."

Other Lamellicorn Beetles.

The larvæ of the beetles briefly mentioned below all live in the soil, or in decaying wood or in dung. Hence, it is not surprising that all of them strongly resemble the larva of the cockchafer. Moreover, these beetles themselves display a considerable amount of resemblance to the cockchafer (explain this more fully), for all of them on the completion of their metamorphosis have to work their way up to the light, all feed upon vegetable substances, and all are obliged to bury their eggs.

The familiar yellowish-brown **June Beetle** or **Small Cockchafer** (*Rhizotrogus solstitialis*) represents a cockchafer in miniature (explain names). On roses and other flowers we often find the golden-green **Rose Beetle** (*Cetonia aurata*), which resembles a glittering gem. These insects feed on the tender portions of the blossom, and with the brush-like portions of their maxillæ lick up the sweet juices of the flower. Their larvæ live in rotten wood, and frequently also enter the lowest decayed layers of the nests of the red ant.

Among the numerous species of beetles which consume the dung of cattle, the best known are the **Dung** or **Dor Beetles** (*Geotrupes*). They are large and mostly of a lustrous steel-blue colour. Even from a considerable distance they scent their unsavoury food. Where the soil is loose the beetles burrow out vertical canals beneath dung-heaps, into each of which the female deposits an egg, and also a portion of dung to serve as food for the larva hatched from the egg. When roughly handled these beetles emit a stridulating noise (see burying beetle). This is caused by the friction of the coxæ of the hinder pair of legs against the sharp edges of the third abdominal somites. The dung beetles as well as the burying beetles are frequently much infested by beetle-mites (*Gamasidæ*). Related to the dung beetle is also the **Sacred Beetle of the Egyptians** (*Ateuchus sacer*), which lives in South Europe and North Africa. In this species the male and female, after the latter has laid an egg in the dung, make a pill of the latter, which they bury in the earth. The old Egyptians held this insect as sacred, and frequently perpetuated its image on a very large scale in stone (scarabæi).

Digitized by Google

The chestnut brown **Rhinoceros Beetle** (*Oryctes nasicornis*) and its larva are frequently found in tanners' spent bark and the mould of manure-beds. The male is distinguished from the female by a horn on the head (hence the name), and a three-toothed prominence upon the prothoracic shield.

A still greater difference between the sexes is displayed in the largest of our European beetles, the **Stag Beetle** (*Lucanus cervus*). In their antler-like mandibles the males possess formidable weapons for the contests in which they fight for the females, who are much fewer in number. The food of these handsome beetles consists of the juice of so-called "bleeding" oaks, which they lick up with the "tongue," or "lingula" (*i.e.*, the central bilobed hairy portion of the labium; see the bee). The larvæ burrow in the trunks of decaying forest trees.

Family 2: Ground Beetles (Carabidæ).

The Gold Beetle (*Carabus auratus*).

(Length ¾ to 1 inch.)

This species is common everywhere on the Continent, but rarely met with in England except among foreign vegetables. In order to understand the nature of this beetle, it is only necessary to shut it up in the same box with a cockchafer, a caterpillar, a slug, an earth-worm, or any other of the smaller invertebrates; we shall soon discover that we are dealing with a *predatory animal*. The gold beetle, accordingly, is a rapid, nimble creature, which pursues its prey running. Rapidly the long, slender, and very movable *legs* convey the flat, elongated body over the ground. *Wings* are absent; indeed, the swift-footed insect does not need them. The *wing-covers* (elytra), however, are present, being required for the protection of the soft dorsal surface of the abdomen. The strong, sickle-shaped *mandibles* (see illustration, p. 341) are used both as weapons of destruction and as cutting instruments. This beetle pursues its prey in the daytime, and its colour, therefore (unlike that of most of its relatives, which are nocturnal in habit, and therefore dark-coloured), is a brilliant green, which does not render the insect conspicuous among the tangle of plants. The surface of the body, however, which is turned towards the ground is black. When the beetle is attacked by an *enemy*, such as a song-bird or reptile, it emits a brown, acrid, *evil-smelling* juice from near the anus, which in all probability either "spoils the assailant's appetite," or at any rate causes it to hesitate for a moment, during which interval the beetle manages to reach a safe

Digitized by Google

hiding-place. Like all the members of this family, the gold beetle possesses long, filiform *antennæ*.

The *larva* is much more rarely observed than the beetle. During the day it is concealed under stones and similar retreats, and consequently is of black colour. In accordance with its life aboveground, it is furnished with eyes. Its food, like that of the beetle, consists of small invertebrate animals. It is accordingly armed with powerful mandibles, and is a very nimble and active creature. The legs, though well developed, are, however, not sufficient for supporting the flat, elongated body, which moreover is covered with strong plates of chitin, and hence the posterior end of the body is very prominent, and used for supporting and pushing the body (see caterpillar of white cabbage butterfly. Compare the gold beetle and cockchafer and their larvæ in reference to the points here discussed). The gold beetle is a *useful animal*, and the same remark applies to its allies.

Allied Species.

Among these the **Large Gold Beetle** (*Calosoma sycophanta*) is distinguished, not only by its size (above an inch) and beauty (blue-black; abdomen broad, covered by gold-green wing-cases), but especially for its services as forest guardian; both the beetle and its larva running up the trunks of trees in incessant pursuit of the larvæ and pupæ of the black arches moth, the pine lappet (*Gastropacha pini*), the processional moth, and other injurious Lepidoptera. This beetle is called in Germany, on account of its habits, the pupa-killer, but in England it is very rare.

The **Green Tiger Beetle** (*Cicindela campestris*, about ½ inch) is common in sandy fields, etc. On account of its green coat (which is marked with five white dots) it is also called in Germany "the green huntsman." And the beetle is a hunter indeed, pursuing its prey in the warm sunshine both running and flying (wings well developed). The larva also is predaceous. It digs cylindrical burrows running vertically into the ground, from which it pounces suddenly upon its prey.

The **Corn Beetle** (*Zabrus gibbus*) forms a single exception among the ground beetles, being, like its larva, a vegetable-feeder. This beetle often does great damage to wheat-fields, the larvæ cutting down the growing plants, and the beetles consuming the ripening grain. The beetle is about ½ inch long, and of dark (black) colour, in accordance with its nocturnal habits.

Digitized by Google

Family 3: Water Beetles (Dyticidæ).

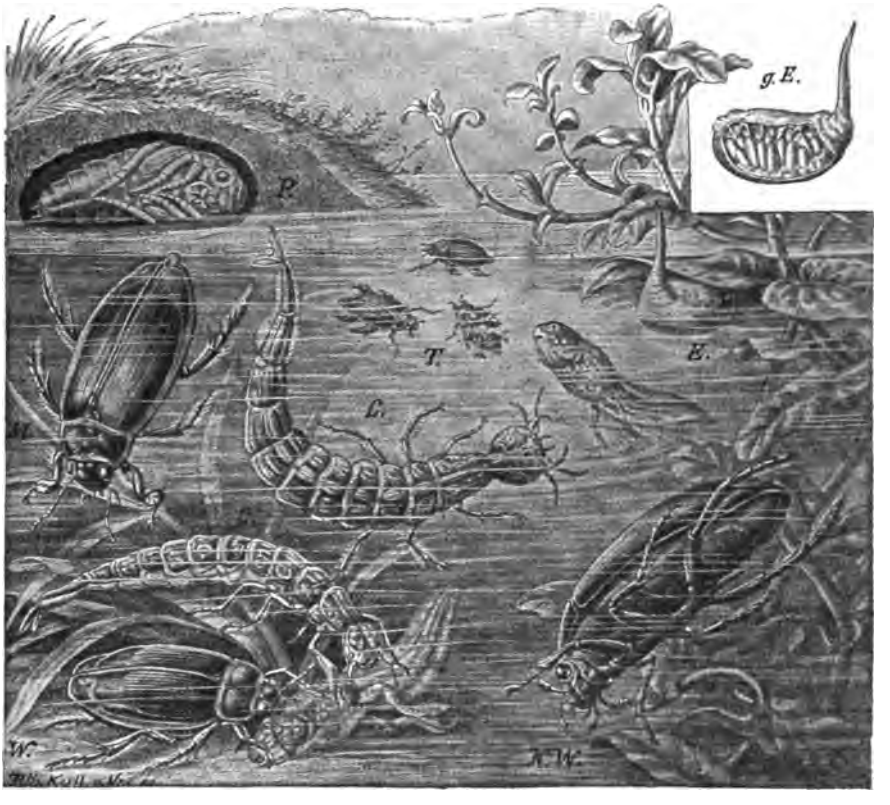
The Common Water Beetle (*Dyticus marginalis*).

(Length about 1¼ inches.)

The water beetle and its allies are, in contrast to all other beetles, aquatic animals, and hence in many parts of their anatomy exhibit an entirely different structure from that of other Coleoptera. To understand its structure and habits, the insect should be put into an aquarium. If in thus transferring it the beetle is somewhat roughly handled, it emits from the anterior and posterior margins of the prothoracic shield an evil-smelling *milk-white fluid* by which it tries to alarm us (and any other enemies). (Compare with gold beetle, etc.) Like many other aquatic animals (give examples), the beetle is much darker on its upper than on its under surface, and when at rest on the dark bottom of a pond or among the confused tangle of water-plants cannot easily be distinguished (under side yellowish-brown, upper side dark olive green; prothoracic shield and elytra with yellow margins—hence its specific name). As, like all other insects, the beetle breathes by *tracheæ*, it has periodically to ascend to the surface of the water. In doing this, it protrudes the end of the abdomen for a moment above the water and slightly raises the wing-covers, under which are situated the spiracles (show these). In this way the used-up air is expelled and pure air taken up. Having thus supplied itself with a fresh store of air, in the shape of a silvery bubble of air adhering to the hairs of the back under the elytra, the beetle once more dives below the surface (compare with the water spider). Notice how nimbly and rapidly it swims, its flattened, sharply-margined *body* cleaving the water with ease, and the *hind-legs* acting as effective oars. Notice also the peculiar structure of these limbs (natatorial legs). They are very long (the third thoracic segment is for this reason the largest; see cockchafer), and are capable of being moved only from behind forwards, and in the reverse direction (by what arrangement is the motion thus limited?); all their parts are strongly compressed laterally, and the tibia and joints of the tarsus are covered with two rows of strong hairs, by which the rowing surface is considerably increased. The first and second pairs of legs, though locally furnished with hairs, are in other respects constructed like those of land beetles, being, in fact, used much less for swimming than for climbing among and holding on to the tangle of water-plants and for progress on land (see also below). The three first tarsal joints of the front-legs of the male assume the form of large disc-like suckers, which are used

Digitized by Google

for clasping the female. The latter, moreover, is distinguished from the male by having its *elytra* (usually) furrowed. If its native pond dries up or the beetle desires to find one more richly supplied with food, or to spread its progeny over a wider area, it spreads its large wings and takes to flight. (For this reason we must keep our aquarium covered over.) The *predaceous and voracious* character of this insect may be



WATER BEETLES. (Natural size.)

Common Water Beetle (*Dyticus*): M., Male; W., female; L., two larvæ; P., pupa. *Great Water Beetle* (*Hydrophilus*): K.W., female; E., a packet of eggs under a leaf, shown open at g.E.; T., three whirligigs.

easily proved by introducing other aquatic creatures into an aquarium containing captive water beetles. All, from the delicate May-fly to the worm and fish, fall an easy prey to it, and it even bites holes into the bodies of the larger fishes and frogs. Hence the water beetle is a *rapidly moving* creature (see above) and equipped with powerful *pincer-like mandibles*.

Digitized by Google

But the beetle is excelled by its olive-green larva in ferocity, though, strange to say, the aperture of the mouth in this formidable creature is very small and quite useless for the reception of food. Its place is supplied by the powerful pincer-shaped mandibles, each of which is perforated by a canal. When the larva pierces the body of its victim with these instruments, it injects through the canal a drop of a brownish saliva which is poisonous, and kills the prey and also dissolves the soft parts of its body. (Allow a larva to bite into a piece of meat.) The parts so dissolved (*i.e.*, digested outside of the body) are then sucked up, so that nothing is left of the prey (in the case of an insect) but the empty chitinous skeleton. The legs, as in the beetle, are furnished with bristles. But locomotion is chiefly effected by undulatory movements of the worm-shaped body. (Compare with ringed snake and eel.) For the purpose of breathing, the larva elevates above the surface of the water two long tubes situated at the end of the abdomen, and each bearing a small plate covered with hair and proof against wet. All other aquatic insect larvæ also breathe by air-tubes; for, inasmuch as finally they develop into animals passing their life in the air, they must be provided with respiratory organs adapted to an aërial existence. (Compare larvæ of dragon flies and May flies.) The larva finally burrows its way into the earth outside of the water, and there passes into the *pupa* stage.

Allied Species.

The small black beetles often seen gyrating in endless "figures of 8" on the surface of the water, suddenly diving down on the approach of danger, but soon reappearing to continue their play, are known as **Whirligig Beetles** (*Gyrinus natator*). They are adapted for these peculiar movements by a broad, flattened body and their fin-like middle and hind legs. The front-legs (prehensile legs), on the other hand, are elongated and arm-like, and are used for seizing the prey, which consists of all sorts of small water animals. The largest of all the water beetles (reaching a length of about $1\frac{3}{4}$ inches) is the pitch-black **Great Water Beetle** (*Hydrophilus piceus*). Its antennæ are club-shaped. Though its middle legs have the form of oars, this insect is not nearly as good a swimmer as the common water beetle, its body being high, stout, and provided with blunt edges. Hence its food consists chiefly of vegetable substances. This beetle packs its eggs into a very neat-looking web, which swims on the water like a small bladder provided with a chimney for ventilation. The larvæ are very similar in appearance to those of the common water beetle, and of the same predaceous habits.

Digitized by Google

Family 4: Carrion Beetles (Silphidæ).

The Sexton or Burying Beetle (*Necrophorus vespillo*).

(Length ¾ inch.)

If the dead body of a small vertebrate be allowed to lie exposed in the open air, a large number of carrion beetles soon make their appearance, among which burying beetles are certain to occur. The beetle is black, but easily distinguished by two red or yellow bands on the wing-covers. The latter are very short and do not completely cover the abdomen; hence the uncovered portion of the dorsal surface, like the under side, is strongly chitinized. (Contrast with cockchafer and others.) By the help of their remarkably keen sense of smell (antennæ club-shaped) these beetles, even from a distance, scent the carrion on which they, as well as their larvæ, *feed*. To prevent, however, other carrion-feeders from snatching the spoil from their offspring, the solicitous parents bury the carcase (hence the name). As a rule, several individuals unite in this work, creeping underneath the dead animal and scraping away the earth so that the carcase sinks slowly down into, and finally disappears in, the ground. The beetle is equipped for these operations by the possession of digging or *fossorial legs*. The middle and hinder pairs of legs are especially strong, and the second and third thoracic segments are correspondingly larger than the first (see cockchafer, Section A, 1, *d* and *e*). After the carcase has been buried the female deposits a number of eggs in it, in this way richly providing food for the emerging *larvæ*. The beetle is protected against the attack of insectivorous enemies by its musk-like smell and also by an ill-smelling fluid which it exudes when attacked (see gold beetle). The insect can produce a creaking sound by the friction of two furrowed longitudinal bars against a transverse bar placed under the ends of the wing-cases. As this sound is only emitted when the beetle is attacked, it probably serves as a means of inspiring fear in enemies. (Compare with the hissing of snakes, the spitting of a cat, etc.) These protective arrangements do not, however, frighten off the troublesome beetle-mites, which crawl on to this insect as well as humble-bees and dung-beetles during their stay on or in the ground.

SEXTON OR BURYING BEETLE, WITH THE ELYTRA RAISED AND THE HIND-WINGS UNFOLDED TO SHOW THE TWO FURROWED LONGITUDINAL BARS *r*. (About natural size.)

Digitized by Google

Allied Species.

The **Black Carrion Beetle** (*Silpha atrata*) may often be met with upon roads. It is about ⅓ inch long, black, and emits an abominable smell. Its larva, in the absence of carrion, will also eat vegetable substances, and often does much damage in beetroot-fields.

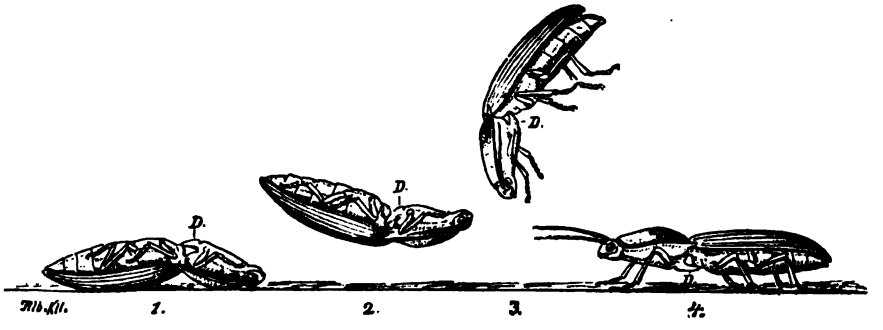
More distantly related to the useful burying beetle is the **Bacon Beetle** (*Dermestes lardarius*), a highly injurious insect, frequently met with in houses, where both the beetle and its larvæ make themselves unpleasantly familiar by attacking meat, skins, furs, etc. The beetle is about ¼ inch long, and black, with the exception of a broad, grayish-yellow band at the base of the wing-cases, by which it may be easily recognised. When touched, even quite gently, the beetle at once simulates death (see click beetles).

Family 5: Skipjacks, or Click Beetles (Elateridæ).

Like many other insects, the click beetles on the approach of danger instantly allow themselves to drop *to the ground*, where they disappear, often completely—especially in the grass—from the sight of their enemies. The skipjacks use an additional means of protection; they draw up their legs, lay the coxæ in furrows of their body armour (some do the same also with their antennæ), and remain motionless in this position until the danger seems past; in short, they *pretend to be dead*. Hence they are nearly certain to remain untouched by such predatory animals as are in the habit of feeding only on prey which they themselves have slain, whilst reptiles and amphibians, which only observe moving animals, are most likely to overlook them. If these beetles in falling happen to alight on their back, they are unable to touch the ground with their legs, which are remarkably short; they are then, however, capable of *skipping upwards* (name), which is effected as follows: Before jumping, the beetle arches its back, so that only the prothoracic shield and the tips of the elytra remain in contact with the surface of support, and then wedges a spiny process developed upon the middle of the under surface of the prothorax firmly against the edge of a groove in the second thoracic segment. The muscles of the body are next contracted with such force that the spine slips from its abutment (the edge of the groove), and snaps into the groove with a sharp, clicking sound; the back of the insect is thereupon arched with such force that it impinges violently against the supporting surface, and the beetle is hurled violently upwards by the force of the recoil. The whole

Digitized by Google

process is somewhat like "snapping one's fingers," in which act we press the middle finger firmly against the thumb (abutment) and allow it to glide off suddenly; in this way much force is exerted, and, as is well known, a slight explosive sound produced. With this peculiar faculty of motion of the Elateridæ, the *great mobility of the first thoracic*



AN ELATER (SKIPJACK).

At 1, lying on its back; at 2 and 3, in the act of skipping, and thereby, as shown in 4, landing upon its legs. D., Spine of the first thoracic segment (prothorax).

segment (*prothorax*) and the *elongated shape* of these insects are closely correlated.

The "wire-shaped" larvæ of several of the Elateridæ, bearing a strong resemblance to the well-known meal-worm, are known as "wire-worms," and often do considerable damage by destroying the underground portions of the stems of root, grain, and fodder crops. One of the most destructive is the **Striped Click Beetle** (*Agriotes lineatus*). It measures about ¼ inch in length, and is dark gray with yellowish striped wing-covers.

Family 6: Malacodermata.

The Glow-worm (*Lampyris splendidula*).

(Length about ⅓ inch.)

On warm summer nights—about St. John's or Midsummer Day—meadows and bushes are frequently illumined by numerous radiant little lights. They are the lamps lit by the glow-worm, or St. John's worm, as it is called in Germany, from the time of its appearance. If one of these fiery sparks is caught in its flight through the air, it will turn out to be the *male* of this beetle, which is of a grayish-brown colour, with two colourless transparent spots on the prothorax, and with leathery, soft wing-covers. If, on the other hand, one of the small lights is taken

Digitized by Google

up from the grass, it is found to be a *female*, which is of a whitish-yellow colour, without wings, and only possesses very short, scale-like wing-covers. In both sexes four white spots are discernible on the under surface of the body, which represent the *luminous organ*. Now, what is the use of this luminosity? In the first place it is a means of *recognition for the sexes;* guided by it the male can discover the female, which is incapable of flight, even on the darkest night, whilst the female in its turn will be able to observe any male in its proximity. Secondly, the luminosity very probably serves as a means of frightening enemies; for we find that the *eggs* and *larvæ* are also luminous, though in a less degree than the beetle. The larvæ are worm-like, slender and active creatures; they are of predatory habits, living chiefly on snails. Hence, like the beetles, they are mostly found in *moist localities*.

Family 7: Blistering Beetles (Vesicantia).

The Oil Beetle (*Meloe proscarabæus*).

(Length up to 1¼ inches.)

The oil beetle is an insect of very striking appearance. In the spring it may be seen crawling heavily and lazily over the grass, to which its shiny blue-black body stands in sharp contrast. This, however, is in nowise a disadvantage to the insect, which is a vegetable-feeder, and finds its favourite food (grass, leaves of dandelion and other plants) with ease and in abundance, and is, moreover, in the happy position of being *avoided by all insect-eating animals*. For when touched the insect secretes from the joint between the femur and tibia an acrid, yellow, oily liquid (hence the name), which even the hungriest of insect-hunters shuns with disgust. Investigators have found that this liquid is nothing but the blood of the insect. (Compare with spotted salamander.) This provision, too, enables the beetle to dispense with wings, and the *wing-covers* also are very short. The minute larvæ of the oil beetle crawl upon flowers, and thence attach themselves to the bodies of humble and other bees, by whom they are conveyed to their nests, and there they live as parasites and undergo their metamorphosis. As, however, many of the larvæ perish in the course of their transportations, the number of *eggs* produced by the beetle is very large, as may be seen by the bulky, distended *abdomen of the female*.

A closely-allied species is the **Spanish Fly** (*Lytta vesicatoria*). It is about ¾ inch long, and metallic green in colour, thus presenting but a slight contrast to the green leaves of the ash and elder on which it lives,

Digitized by Google

whilst its strong, unpleasant smell probably renders it unpalatable to all insect-eating animals. For the preparation of the well-known blistering plaster (name of family) the beetles are collected, dried, and ground to powder.

Family 8: Weevils (Curculionidæ).

The Apple-Blossom Weevil (*Anthonomus pomorum*).

(Length about $\frac{1}{8}$ inch.)

If an apple blossom looking brown and shrivelled, as if scorched, in fact, be opened, a small insect *larva* will be found inside which lives on the stamens and pistils of the flower. This larva is eyeless and white, living in the dark (see cockchafer), and also limbless, and hence termed a maggot, since it is not obliged to journey from one place to another (see bee). About the middle of May the larva enters into the *pupa* stage, and about eight days later a small beetle, the apple-blossom weevil, emerges from the shrivelled blossom. Now, how has the maggot got into the flower? The beetle has simply deposited an egg in the bud. This has been effected, not by means of an ovipositor, as in the ichneumon flies and their allies (which see), but by the help of the head, which in this insect is prolonged into a long *rostrum* or *proboscis* (as in a shrew-mouse), at the end of which is placed the small mouth with its *masticatory organs*. By means of the relatively strong mandibles (the other mouth parts are very small) the beetle gnaws a narrow deep hole in the bud. It then lays an egg in the opening of the passage, and pushes it with the proboscis onward to the stamens. It might be supposed that in this operation the antennæ get in the way. These, however, are bent back, their lower portion being laid in a *furrow of the proboscis* when the latter is pushed into the bud. The *food* of the beetle consists of the leaves of trees. As the eggs are not deposited until the following spring, it is compelled to hibernate. It then leaves its crannies and ascends the trunks of the apple-trees. The careful fruit-grower, however, stops the progress of the destructive creature by rings of sticky gum before it can do any damage. On account of its *bark-like colour* (blackish-brown with grayish hairs and a white band on each wing-cover), the beetle cannot easily be recognised when creeping up a tree-trunk, nor is it easy to discover it on the ground, to which it allows itself to drop on the approach of an enemy (see skipjack). Its *hard chitinous covering* is a further by no means unimportant protection to the insect. (What do you frequently observe when you are putting pins

Digitized by Google

through collected specimens of weevils?) The number of weevil species is legion. The larvæ of all live in the inner parts of plants, whence the beetles also have all essentially the same structure. The proboscis is shorter or longer according as the beetle has to bore to a greater or less depth before it reaches that portion of the plant which happens to serve as food for its larva.

The "worms" inside of hazel-nuts are the larvæ of the bark-coloured, long-snouted **Nut Weevil** (*Balaninus nucum*; length about ¼ inch). The maggots gnaw a hole through the shell (so-called "worm-hole") and pass into the pupa stage in the earth.

In barns and granaries considerable damage is frequently done by the black corn-worm, *i.e.*, the larva of the **Corn Weevil** (*Calandra granaria*; length about ⅛ inch), which devours the contents of the grain, leaving nothing but the empty husks.

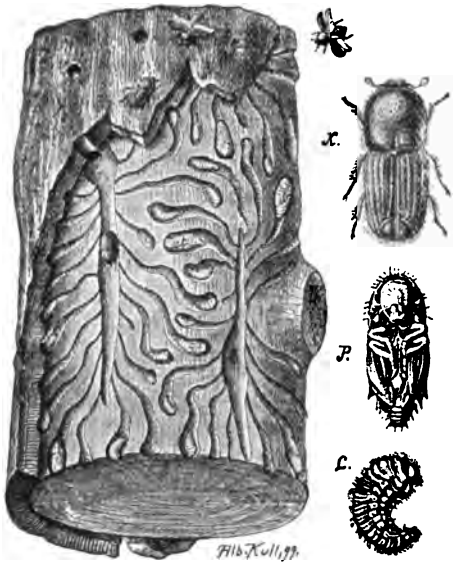
Family 9: Bark Beetles (Bostrychidæ).

The bark beetles afford a remarkable illustration of what great results may be achieved by the united efforts of agents individually weak. None of these insects are more than a small fraction of an inch in length, and they live almost exclusively on or within the woody parts of trees, their *food* consisting of the wood, bast or bark, which they loosen with their sharp mandibles (the indigestible materials remain behind in the passages as "worm-dust"). A few of these beetles could hardly damage a tree seriously, but when some thousands have made their nests in it, it must finally succumb. By their united efforts these minute creatures manage to overthrow the most venerable of our forest giants, and even *devastate* extensive woods.

One of the most formidable of these pests is the **Common Bark Beetle** (*Bostrychus typographus*). It is about ⅛ inch in length, varying in colour from dark brown to straw yellow, and lives under the bark of pine-trees. In the spring it seeks out a tree which seems suitable for its offspring; it gnaws its way through the bark, and erodes a vertical passage or canal ("mother passage"). Lateral niches pass off from this passage, in each of which the female lays a single egg. The escaping larvæ, which are eyeless, colourless and legless (see apple-blossom weevil and others), now eat their way into the bast or bark along passages running perpendicularly, or at an oblique angle to the mother passage. These "larval canals" continually increase in width, and finally terminate in a dilatation, the so-called "cradle," in which the larva enters into the pupa condition. In the following spring the

Digitized by Google

perfect beetle bores a vertical opening (bore-hole) through the bark, by which it leaves the tree. By the crossing and interlacing of the larval canals, peculiar figures, resembling printed type, are frequently formed, whence in Germany the beetle is also known under the name of "the printer." As may easily be observed, the passages under the bark often display a different form and arrangement to that described above. In such cases they are due to different species of beetles.



COMMON BARK OR "PRINTER" BEETLE.

Portion of a branch showing mother and larval canals, with bore-holes, beetles, larvæ and pupæ (natural size). The same on the right side of the figure (about four times natural size). K., beetle; P., pupa; L., larva.

Family 10: Longicorn Beetles (Cerambycidæ).

These handsome, *elongated* beetles have received their name from the long antennæ which they usually carry curved over the back like the horns of a goat. When touched, they usually emit a sharp *squeaking noise* (see burying beetle), produced by rubbing the posterior margin of the prothorax against a finely-grooved process of the mesothorax. The larvæ live in the inner parts of plants, mostly in the wood. They are accordingly (as a rule) eyeless, colourless, and provided with powerful mandibles (see apple-blossom weevil, bark beetle, etc.). In many of them we find, both on the dorsal and abdominal surfaces, strongly chitinized transverse protuberances, by the aid of which the larvæ push themselves along through their canals. (Compare with the pro-legs of caterpillars.)

One of the most abundant of the longicorns is the **Large Poplar Beetle** (*Saperda carcharias*). It measures about 1¼ inches, and is covered with a greenish-yellow down, and with black dots on the upper side. The colour, thus, is not in contrast with the bark of the willow and poplar which it frequents, and the stems of which are bored by its larva. Its habits are nocturnal, like those of the large continental species, *Cerambyx cerdo*, which measures about 2 inches, and is also of obscure colour (black with pitch-brown wing-covers).

Those of the longicorns, however, which fly by day and frequent

Digitized by Google

flowers are of bright and frequently much variegated colours. The most familiar of these sunshine and flower loving insects is the **Musk Beetle** (*Aromia moschata*), which is of a metallic green colour, and derives its name from its strong musk-like smell. (Compare with Spanish fly.)

Family 11: Golden-Apple Beetles (Chrysomelidæ).

These are mostly small insects with a strongly-arched body, and of bright colours. They, as well as their larvæ, as a rule feed on leaves, and often, especially when present in large numbers, do considerable damage. This is especially the case with the **Common Flea Beetle** (*Haltica oleracea*) and its numerous relatives, which are especially destructive to the different kinds of cabbage plants. The first named of these beetles measures about $\frac{1}{8}$ inch, and is of metallic or blue-green colour, and on account of the strongly-developed femora of the hind-legs—a feature common to the family—is an excellent jumper (hence the name; compare with flea and grasshopper). The best remedy against the ravages of this pest are wood-shavings dipped in tar, which are scattered among the plants; as the tar dries with difficulty, the insects stick to it and perish.

Another member of this family, whose appearance in Europe in the seventies spread alarm and consternation far and wide, is the **Colorado Potato Beetle** (*Chrysomela decemlineata*). This insect is a native of America (name), where it and its larva often commit wholesale devastation among the potato crops. Fortunately, it has not become naturalized in Europe. It measures about $\frac{3}{8}$ inch in length, and is of a leather-yellow colour, with eleven black spots on the prothorax and ten black longitudinal stripes on the elytra.

Family 12: Lady-Birds (Coccinelidæ).

The Seven-Spotted Lady-Bird (*Coccinella septempunctata*).

Everyone is familiar with this pretty hemispherical lady-bird. When touched, not only does it pretend to be *dead* and allow itself to *drop to the ground* like the skipjacks and others, but, like the oil beetle, it exudes a drop of an acrid yellow, evil-smelling fluid (*blood*) from between the femur and tibia. For this reason insect-eating animals will either not attack this beetle at all or only when forced by extreme hunger, as has been proved by numerous experiments. For the same reason also, like many other animals which are protected by foul-tasting secretions, this little beetle is marked with a conspicuous *colouring* (describe it), and can nevertheless expose itself without risk to the sight of its enemies.

Digitized by Google

It is, indeed, obliged to so expose itself, since its *food* consists of all kinds of noxious plant-infesting creatures, and especially plant-lice or aphides. These remarks also apply to the *larva*, which likewise is provided with a warning colour (gray-blue with black and red dots), and, in accordance with its predatory habits, is a very active creature, furnished with well-developed legs and distinct eyes. (Contrast it with larvæ which feed on vegetables and live in the dark.) The *pupa* is black and red coloured, and may be found suspended from leaves by the end of its abdomen.

In addition to the seven-spotted lady-bird (why so called?), we have numerous other species of this family resembling it in all the essentials of structure and mode of life.

ORDER III.: HOOK-WINGS (HYMENOPTERA).

MOUTH parts masticatory and suctorial. All the thoracic somites united. Fore and hind wings similar, connected, scale-less, traversed by a few branching nervures. Metamorphosis complete.

Sub-Order 1: Provided with a Sting (Aculeata).

The Honey-Bee (*Apis mellifica*).

(Drones and queen about $\frac{5}{8}$ inch; working females about $\frac{1}{2}$ inch.)

A. The Bee in a State of Domestication.

The honey-bee has been domesticated from time immemorial. It has been spread from its *home* in temperate Asia and Europe over the greater portion of the globe (why is it absent in cold regions?), and, as in the case of all other domesticated animals (examples), several varieties or *races* of this insect have been produced.

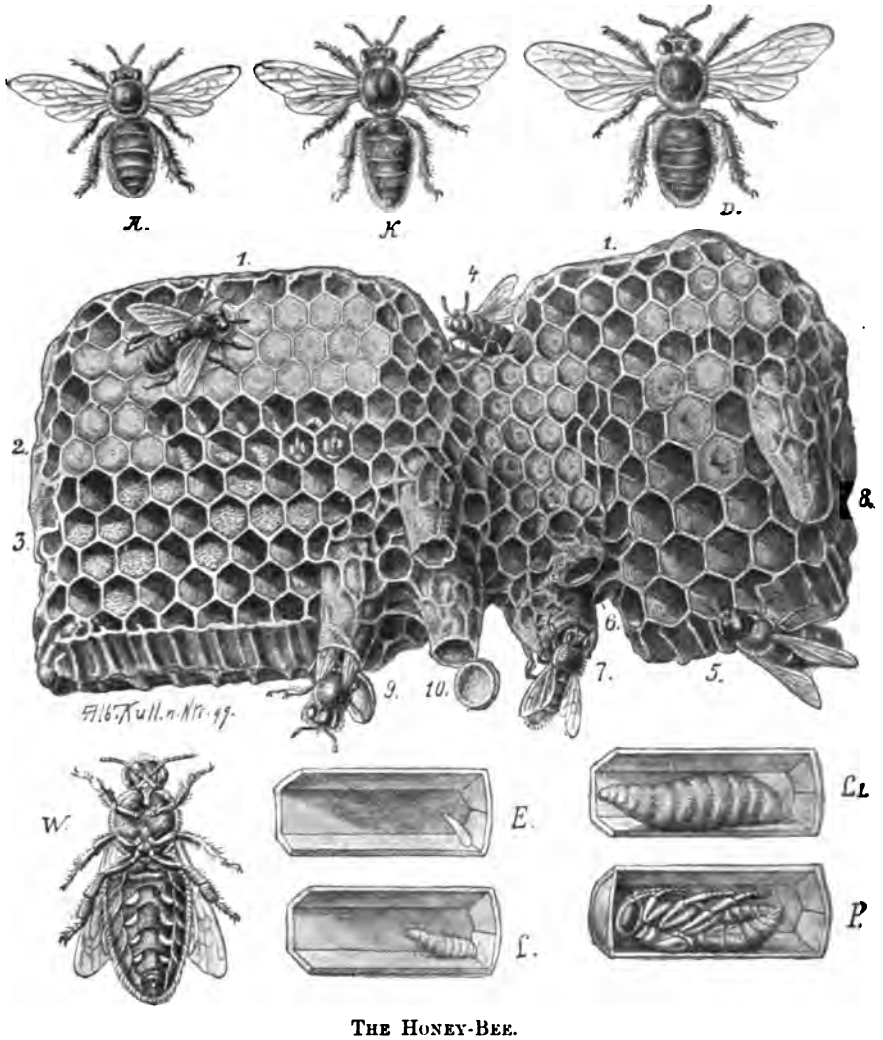
In *hives*, *i.e.*, boxes or baskets made of boards or woven of straw, the *bee-keeper* lodges his charges. A small opening in one of the sides of the hive serves as a means of exit and entrance for the insects, and also for the purpose of ventilation. In front of this opening a small shelf is usually placed to facilitate the insects' arrival or departure.

As a reward for his trouble, the bee-keeper takes from the hive a portion of the honey conveyed by his industrious pets into the cells of wax which they construct (honey in the comb).

B. The Bee Community.

1. *Members of the Community.*—A hive is inhabited by from 10,000 to 50,000 individuals, consisting of males and females. The males, or *drones*, only appear in spring, and usually number a few hundreds. They are of larger size than the other bees, and easily recognised by

Digitized by Google



THE HONEY-BEE.

A., Worker; K., queen; D., drone. *Below—a Piece of the Honey-comb:* 1, Cells of the workers partly filled with honey and covered with a "lid" (upon these a worker bee, natural size); at 2, cells with eggs, larvæ and pupæ (the two cells containing pupæ with their lids removed); at 3, cells filled with pollen; 4, passage through the comb, with a worker bee; below it cells filled with honey, and of irregular shape, forming the transition between worker cells and, 5, the larger drone cells (upon the latter a drone, natural size); 6-10, royal cells; 6, the commencement of a queen cell; 7, cell with larva in the act of being fed by a worker bee; 8, closed cell with pupa; 9, cell with a young queen in the act of escaping; 10, empty cell with lid open. *Below, on the Left:* W., worker seen from below, showing colourless lamellæ of wax protruding from between the abdominal rings. *On the Right:* Four cells strongly magnified and divided in two longitudinally; E., with egg; L., with a young, Li., with an older, larva; P, with pupa.

Digitized by Google

their large eyes and stouter abdomen. By far the larger number of the inmates of the hive, therefore, are females, among which, however, one very important difference is noticeable, viz., that a single one only in each hive is capable of laying eggs, all the rest remaining sterile throughout their life. This fertile female excels the others in size, and is distinguished from the drones, which are of about the same size, by its more slender abdomen. This female is the mother of the future generations of bees, the most important among the thousands of individuals of the community, and accordingly distinguished by the bee-keeper as the *queen*. The smaller, sterile females are called *workers*, inasmuch as they perform all the various labours required for the maintenance of the hive. In order to understand these labours and the life of a bee society in general, we will examine a hive from its foundation for a period of a year.

2. *Foundation of the Hive.*—It is a warm day in June, and the earth is smiling beneath the bright sunshine. In the old hives the bees have considerably multiplied, and to-day they are running excitedly about one another; others are hanging in a huge cluster from the alighting-board; they are more given to stinging than usual, and a peculiar buzz resounds from the hive. All this betokens that something remarkable is about to happen. In fact, a young queen will soon be leaving her cell in the hive, as is indicated by the loud "toot-toot" to which from time to time she gives utterance. However, since two queens can never exist side by side in a hive, it will either mean a struggle for life and death between the two, or the older queen must quit the hive. It is the latter event which takes place; for behold a thousand bees rushing forth in wild haste from the door, the old queen in their midst! The bee-keeper calls this exodus *the swarming of the bees*. For some minutes the swarm hovers about in the air; then it settles down upon the branch of a tree. One bee clambers with its legs upon the other, until a large cluster, like a bunch of grapes, hangs down from the branch. The bee-keeper now hastens up and sweeps all the bees into an empty hive, which henceforth will be the dwelling of the new community. This is probably the second swarm from the same hive. If still other queens are produced in the old hive, they are either stung to death or likewise abandon the hive, accompanied by new swarms, each of which consists of smaller numbers than the previous one. The young queen only once (as a rule) during her several years' existence leaves the hive for a lengthened period, for the purpose of engaging in sexual union with one of the drones, which quits the hive at the same time (*nuptial flight*). Soon after the swarming season the drones which have been produced in the spring are killed (*massacre of the drones*).

Digitized by Google

3. *Work in the Bee Community.*—Scarcely has the new home been occupied, when work is commenced. The working females fetch resin from coniferous and other trees. With this so-called *propolis* they close up all the chinks and small holes of their dwelling in order to keep off wet and cold. From the *wax*, which protrudes in the form of small plates or scales from the under surface of the abdomen between the middle somites, they build up their well-known structures, the *honey-combs*. These hang vertically from the roof of the hive, and consist of two rows of cells placed horizontally back to back. All the cells are of exactly the same size (wide enough for the queen to enter, and of the same length as a worker bee; why?), hexagonal, and with the floor forming a basin-shaped depression. Behind the first comb, a second, third, etc., is constructed, until the interior of the hive is by degrees completely occupied.

After the completion of the first combs the queen, too, commences to be active. She steps from cell to cell, depositing an *egg* in each. This business of the depositing of eggs has to be carried on with much industry, since the working females during the working season (summer) only attain to an age of about six weeks. (During her whole lifetime the queen lays about a million eggs.) Only a few days after its deposition, an eyeless (since it lives in the dark) larva escapes from the egg. (Compare with the larva of the cockchafer, the house-fly, and other insects.) Being legless, *i.e.*, a maggot, it cannot leave its birthplace to obtain its own food, and would starve if the workers did not bring it food. And these faithful nurses provide their helpless sister with food so abundantly that in a few days it has grown to such a size as almost to completely fill the cell. The workers then close this cell with a waxen lid; the larva surrounds itself with a thin silky web (see silkworm) and becomes a *pupa*, in which the limbs are free from the body (see cockchafer).

When the metamorphosis to the perfect insect is complete, the young bee pushes the lid away from its prison and mingles with the swarm of workers. During the first weeks of its life it only performs "domestic tasks," such as looking after the young brood and keeping the home clean; afterwards, however, it flies out with the others to the flowers to fetch and carry home food for itself, the brood, the workers who are busy in the hive, the queen, and the drones (if any are present). In the spring the bees construct beside the worker cells also larger cells, in which drones are produced from eggs of a special kind (drone cells), and a few very large cask-shaped cells, in which the young queens grow up under the most careful nurture (royal cells). The queens are produced from exactly the same eggs as the worker females, but, as we have just

Digitized by Google

seen, are developed in a larger space, and in the larval condition are probably supplied with food in larger quantity and of better quality than the rest.

Bees accordingly construct their dwellings for the sake of their progeny. This, however, is of importance also to the bee society; for since each of the helpless larvæ inhabits a separate chamber (cell), it receives much better nurture, and is much less liable to be disturbed during its pupal rest than would otherwise be the case. In consequence of this careful nurture only a few of the larvæ perish, especially as they are developed in a closed space like the hive, where they are protected against wet, cold and enemies. But in proportion as the number of bees (workers) in a hive is greater, so much better will be performed all those various tasks which are necessary for the maintenance and welfare of the community. One of the most important of these tasks we shall immediately become acquainted with in briefly considering—

4. *The Winter Rest of the Bee Community.*—The *temperature* of a beehive, even in a severe winter, *does not as a rule fall below* 10° C. (= 50° F.). Indeed, were it to sink much below this, the bees would become numbed with cold and perish, as may often be seen in the open on spring days or on very cool evenings in summer. Whence is this heat in the hive derived? In the body of a bee, as in that of every other animal, heat is produced by the oxidation of material (see Part I., p. 7); in the present case, of course, as in all "cold-blooded animals," this heat amounts to very little (see Part II., p. 229). A portion of it is lost to the surrounding air, if that happens to be cooler than the body of the insect. Now, since the bee is shut up in the hive, its temperature will be raised to some extent, and since, of the thousands of bees which inhabit the hive, each gives up some of the heat it produces to the air of its dwelling, we in this manner get the resultant temperature of the hive.

This will also explain why bees in winter *do not become rigid from the cold, or enter upon a winter sleep* (hibernation), like insects which pass their winter in solitude in the open air. However, if bees during the long winter season abstained altogether from food, they would gradually cool down, until finally they would be numbed by the cold and freeze, for, as we know, the body heat of an animal is produced solely by the combustion of the ingested food. Now, whence is food obtainable during this season, when all the flowers have long since died, and when an excursion into the cold air would be attended with fatal consequences to the insects? *The food required at this season has, in fact, to be stored up.* Accordingly, during the flower-laden season, the bees fill a part of their comb with honey and pollen, closing each of the honey-cells air-tight with a lid of wax to prevent the precious stuff from

Digitized by Google

spoiling. By the time this store is consumed spring has arrived once more, and invites our little insect to its richly-laden banquet. *Thus the structures built by the bees are not merely nurseries* — as we have seen above—*but also serve as store-rooms or larders for a time of need.* (When are the bees obliged to encroach on their reserve store even in the summer? Why may the bee-keeper only abstract a portion of the honey stored up by the bees? When is it even necessary to feed the bees?)

On reviewing the mode of life and actions of bees, as described above, we are driven to conclude that a careful division of labour among its individual members prevails in the hive, no member of the community existing for itself alone, but always for the community. The hive, in fact, represents a *well-ordered society or community*, which (like the largest communities of men) we may describe as a *State*, the members of which represent a *people or nation*.

C. Structural Arrangements by which the Bee is adapted for its Various Activities.

In order to consider this subject, we will follow a bee on its excursion to the source of its food-supply, and in so doing will note all other facts still requiring explanation.

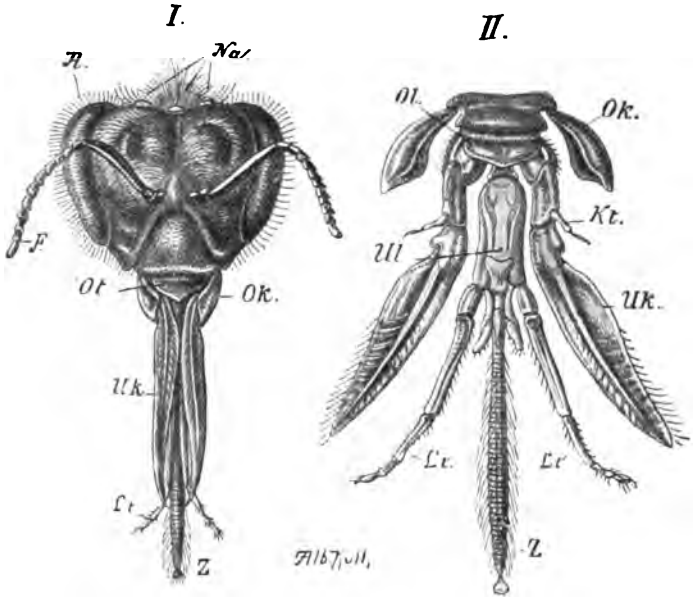
1. *How the Bee finds its Food.*—Numerous experiments have shown that, in spite of its two large *compound eyes* and the three small *simple eyes*, the bee cannot see distinctly, or distinguish colour for a greater distance than from 3 to about 6½ feet. Hence, it must be guided from a distance to the sources of food by the *smell*, which probably has its seat in the short, elbowed *antennæ*. By the smell, too, the many thousands of bees in a community recognise each other, for, as naturalists have proved by laborious researches, each bee society has its own peculiar "hive-scent." In the dark hive the bee is probably also guided by the *sense of touch*, of which the antennæ are likewise the organs. Bees are evidently also endowed with *hearing*, for we have seen that they perceive the peculiar sounds uttered by the young queen bee before swarming (see Section B, 2).

2. *How the Bee reaches the Source of its Food.*—Honey and pollen are the chief materials which the bee seeks out for its food. In nature, however, these substances are only present in small quantities, so that an animal compelled to crawl from flower to flower could not possibly satisfy all its wants thereon. This is only in the power of an animal *provided with wings*, like the bee. The latter, however, besides satisfying its own individual needs, has further to convey food

Digitized by Google

to the larvæ and those members of the family which do not leave the hive, besides having to lay up a store for the winter. Accordingly, a very large number of flowers have to be visited, and the bee, therefore, must be capable of *rapid and nimble flight.*

(*a*) Hence, not only are all the *four wings* used as flight organs (contrast with beetles), but those of each side form a connected and continuous surface, forming each, in fact, one large wing. This connection is effected by the middle portion of the posterior edge of the



I. Head and Mouth Parts (folded together) of Honey-Bee. (Magnified about twelve times.)

II. Mouth Parts (spread open). (More strongly magnified.)

A., Compound eye; Na., the three simple eyes (*ocelli*); F., antenna; Ol., labrum; Ok., mandibles; Uk., maxillæ, with, Kt., maxillary palpi; Ul., labium; Lt., labial palpi; Z., central division of labium, or lingua.

fore-wing being reflected and grasped by some fine hooks on the adjacent edge of the hind-wing. (In the humble-bee these hooks, as well as the other details of structure here mentioned, may be observed with a simple hand lens.)

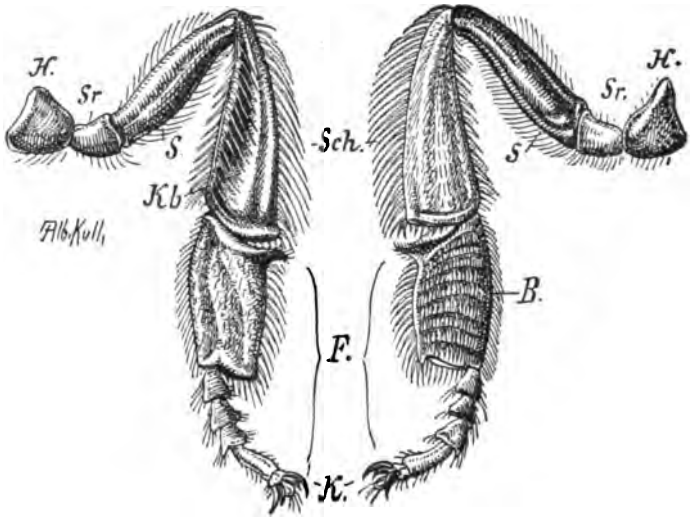
The rapid motion of the wings during flight gives rise to the *humming sound.* If a bee be held fast so that it cannot move its wings, we still hear a sound, but a louder one and pitched in a higher key. This is the real *voice* of the bee, and is produced by forcible expirations of the

Digitized by Google

air through the spiracles (similar, therefore, to the human voice). This voice the bee can control voluntarily (*e.g.*, the "tooting" of the queen before swarming).

(*b*) Since the movements of the bee are very largely carried on by the wings, all the thoracic segments are firmly united (see p. 311, and compare with cockchafer, p. 340).

3. *How the Bee collects its Food.*—(*a*) Having observed a flower which can supply it with food for itself and its family, the bee alights upon it, and by means of the two hook-like, double-pointed claws at the end of each of the last tarsal joints it lies anchored, as it were, to the



LEFT HIND-LEG OF A WORKING FEMALE HONEY-BEE. (Strongly magnified.)
On the left, viewed from the outer side; on the right, viewed from inner side.
S., Femur; Sch., tibia; F., foot; K., two pointed claws with balls between them; Kb., basket; B., brush.

swaying blossom. Between each pair of claws, moreover, we find a "pad" or "ball" (see house fly), by means of which a still firmer attachment is secured, so that, however steep or smooth the supporting surface, the insect cannot drop.

(*b*) As soon as the insect has settled, its mouth parts enter into action; these partly represent an apparatus adapted for sucking up flower-juices (nectar), partly have the form of pincer-shaped organs adapted for biting.

The *maxillæ* and *labial palpi* are elongated structures, so shaped that when folded together they form a tube. Within this the central division

Digitized by Google

of the labium, *i.e.*, the lingua or tongue, which is elongated, pliant, and beset with setose hairs arranged in whorls, can be moved backwards and forwards. When desiring to suck, the bee protrudes the tongue far out of the tube and dips it into the sweet juice, so that the whorls of hairs soon are completely soaked with it. On now retracting the tongue the juice gets into the surrounding tube, and is thence sucked up into the mouth. (Thus the juice is first lapped up and then sucked in. Why is it of importance that the tongue should be of great length and very flexible?) With the help of this suction apparatus the bee also drinks water.

The pincer-shaped *mandibles* are, in accordance with their shape, used after the manner of pincers. With their help the bee detaches and consumes the pollen dust, bites off the propolis, kneads the wax, and carries both to the place where they are required, and also carries out of the hive refuse, the dead bodies of its sister bees, etc. Before the mandibles enter into action, the suction apparatus is folded back below under the head.

Thus the mouth parts are adapted to quite different functions, being used at once for *lapping*, *sucking* and *biting*. The drones and the queen do not share in these actions, and their mouth parts are accordingly much less developed than those of the worker females.

(*c*) We know, however, that the bee has also to bring back from its excursion food for its hungry larvæ and sister bees, as well as to contribute to the common store. It requires, therefore, structural provisions for collecting and transporting these materials. The flower-juices are conveyed in the *œsophagus*, which towards its termination widens out into a sac (honey-stomach), and which can be shut off from the true or digestive stomach by muscles. By the addition of special secretions the juice sucked up acquires a peculiar taste and smell, or, in other words, *is converted into honey*. Arrived in the hive, the bee gives up this honey by regurgitating it.

(*d*) In entering the flower the bee, in consequence of its motions, involuntarily rubs off some of the pollen dust, which adheres to its *hairy* body, so that the insect often looks as if it had been powdered. A small magnifying power shows that most of the hairs are branched, and therefore specially adapted for retaining the pollen dust.

(*e*) The receptacle in which the pollen dust is carried home consists of a depression on the outer side of the tibiæ of the hind-legs. It is appropriately termed the *basket*, and is enclosed by a fence of long hairs partly curved inwards, which prevents the little balls of pollen from dropping out. Now, how does the bee fill these baskets? With the help of its *hairy and very movable legs*, it brushes the pollen dust from

Digitized by Google

its hairy coat towards the under surface of the body, and thence to the hind-legs, which are provided with an organ (a kind of "sweeping brush") for sweeping the dust together. This consists of several transverse rows of short stiff hairs, known as the *brush*, and situated on the inner side of the first tarsal joint, which is very large. When the bee, therefore, wipes the brush covered with pollen dust against the femur of the opposite leg, the baskets are filled with the pollen balls. Coherent masses of pollen the bee removes from the stamens by means of its mandibles, seizes them with its front-legs, and passes them on to the hind-legs. Dry pollen dust (*e.g.*, of plants which are pollinated by the wind) is first moistened with honey vomited up by the bee. The propolis is also collected and carried home in this manner. Drones and queens do not possess these collecting organs.

D. The Bee in its Relations to other Organisms.

1. The existence of the bee, as we have seen, depends on that of flowers. Like most insects, however, which visit flowers in search of food, the bee renders its food-providers a most valuable service in return, for by carrying to the stigma of the same or another flower pollen which may happen to adhere to its hairy body it effects its pollination or fertilization. More than that, being obliged to visit (like its nearest relatives, the numerous wild species of bees and humble-bees) a large number of flowers in order to collect a sufficient amount of honey, the bee becomes one of the most important agents of plant fertilization in Nature. (Compare Goethe's "Gleich und Gleich.")

2. *Enemies.*—With the exception of the honey buzzard, a raptorial bird very similar to the common buzzard, the titmice, green woodpecker, and stork, our native birds are for the most part careful not to attack the bee, whose sting, as we all know, is very painful. The chief enemies of the bee, in fact, belong to its own order (*e.g.*, hornets and wasps), which, excelling it in size and strength, kill and consume it. Fierce contests are also often waged between the bees of different hives, for among bees, too, we find pirates who fight shy of honest work, and desire to get property by stealing. They break into the hives of their neighbours for the purpose of stealing the honey, but, being possessed of a different "hive scent," they are frequently caught by the inhabitants of the hive before they can get to the honey-jars, and punished for their intended burglary with a violent bite or a fatal sting.

The *sting* of the bee (and of its allies) consists of a small, finely-pointed, chitinous tube, provided with small barbs at its end. It is connected with a little bag, in which a poisonous fluid secreted by glands

Digitized by Google

is collected. When this sting enters the body of an animal, a drop of poison is injected through the canal into the wound, where it produces inflammation or, in the case of a small animal, even death. (Compare with poisonous snakes.) Bee-keepers after a time become insensible to the poison. The *abdomen* is connected with the thorax only by a thin tube, and is therefore extremely movable, a circumstance which is of great advantage in facilitating the free use of the sting. In the drones the sting is absent.

Allied Species.

The nearest allies of the honey-bee, besides a large number of other species of bee, are the **Humble-Bees** (*Bombus*). All these insects also industriously visit flowers, and therefore in all essential points of structure resemble the honey-bee. Their societies, however, endure for one summer only, the queens existing through the winter asleep in some retreat, whilst workers and males die in the autumn.

Of the commoner species, we distinguish the **Common Humble Bee** (*B. terrestris*), black, end of abdomen white, and with two yellow bands; the **Garden-Bee** (*B. hortorum*), same colour as previous species, but with three yellow bands; and the **Stone-Bee** (*B. lapidarius*), black, with the end of abdomen red-brown. All these build a structureless nest in mouse-holes, stone heaps, etc. (hence the name). The smaller yellowish-brown **Moss-Bee** (*B. muscorum*) builds its nest among moss.

The Wasp (*Vespa*).

The *colonies* of this insect, like those of the humble-bee, only persist through a single summer, and are likewise founded by queens which have survived through the winter. Their *dwellings*, on the other hand, display considerable workmanship, being constructed of wood fibres gnawed off and chewed up finely by the insects and mixed with saliva. They are found in holes under the ground, in hollow tree-trunks, or suspended in the open from sheltered spots. They consist of several horizontal combs, in many cases surrounded by an additional protecting envelope, composed of several layers, and resembling blotting-paper. For the performance of their labours wasps require powerful mandibles. These also are necessitated by the nature of their food; for though they are fond of sucking the juices of ripe fruits or honey from flowers (on account of the *smoothness of their body* they are of no importance as plant fertilizers; see bee), they are in the first degree carnivorous animals. They seize their prey (bees, flies) on the wing, *sting* it to death, and then consume it, or, after finely masticating it,

Digitized by Google

present it to their larvæ. As "pirates of the air," however, they require to be swift and nimble in their movements (why? give examples), whence we also find them possessed of a long and *slender* body, and very movable abdomen attached by a thin stalk (wasp-like waist). Wasps do not collect pollen or honey, hence the lingua is much shorter in these insects than in honey-bees or humble-bees, and the structural arrangements which adapt the latter for collecting these materials are wanting in them. (Enter into this more fully.) The conspicuous *colours* of wasps (black, with yellow spots) must be regarded, as in the spotted salamander (which see), as a danger-signal for insect-eating birds; and indeed, with the exception of parasites and the honey buzzards, wasps seem to have no *enemies*, no other animal being desirous of making closer acquaintance with the *sting* of these insects. The sting of the largest of our wasps, the **Hornet** (*V. crabro*), is specially dreaded, but the familiar fruit-loving **Common Wasp** (*V. vulgaris*) can also inflict a very painful sting. (Why cannot wasps, however, be slow-moving creatures like others which possess warning colours?)

The Red Ant (*Formica rufa*).

(With a brief consideration of ants generally.)

A. The Societies of Ants.

If on a fine sunny day in summer we walk into a pine-wood and visit the hills of the red ant, we may, if fortunate, observe an interesting episode of life in Nature. The busy crowd of ants with which we have already become acquainted will be found to have undergone a considerable increase in numbers, the thousands of reddish-brown, wingless insects we have seen previously having now been joined by a large number of somewhat larger (about $\frac{5}{8}$ inch) winged creatures, which exactly resemble a small wasp. They are the young *females and males*, who are getting ready for their nuptial flight (see bee). Collecting in large clouds, they now rise and swarm around the trees of the wood. On returning to earth the males usually soon die; the females (queens), of which there are several in each colony, either become the ancestral mothers of new colonies or return to their old nest, which they do not quit again. For this reason, soon after their return they lose their wings, which in the narrow and crooked streets of the ant village would only be an impediment.

The smaller wingless animals ($\frac{1}{7}$ to $\frac{1}{4}$ inch) are the working females, the untiring labourers in the ant dwellings, whom the Bible points out as an example to the idle (Prov. vi. 6; the German for ant, *Die Ameise*

Digitized by Google

or *Emse*, is merely another form for *Die Emsige*, *i.e.*, the "industrious one"). For the execution of the various tasks incumbent on them, with which we shall become closer acquainted in the following sections, these workers principally make use of their pincer-shaped mandibles, which in them are much stronger and larger than in the idle members of the community. For the same reason, since strong muscles are required for the movement of these organs, their *head* also is considerably larger than that of the latter; on the other hand, the thorax, being wingless, is much weaker than in the winged insects. (The communities of all the other ant species are similarly composed, and the same differences exist among their various inhabitants. Among some foreign species, in addition to the ordinary worker females, others with much larger heads and more powerful jaws occur, which are called *soldiers*. It has been observed that these cut up the food into smaller pieces for their weaker fellows, and act as leaders and directors of the expeditions undertaken by the community.)

B. Domicile.

The nest of the red ant is a fine castle, constructed out of the needles of pines and firs, bits of resin and wood, small stones, etc. (Observe how the materials of the nest are collected and conveyed.)

If we clear away a portion of this structure—which extends downwards into the ground about as deep as it rises above it—we observe a labyrinth of holes and tunnels so dark that only an ant could find its way about in them. Truly a wonderful structure, and a gigantic performance for such tiny builders! (Among our native ants different species choose entirely different situations for their dwellings: thus, we may find one species housed between the cracks and crevices of the pavement or of masonry; others take up their quarters under a large stone; here we may see a colony laboriously erecting a structure from earth and sand, which the next rain will wash away; there, again, another has gnawed out chambers and passages in decaying wood or the solid trunk of a tree, etc.)

C. Care of the Brood.

A number of the host of worker females are always fully occupied with the care of the progeny. It is their task to convey to an upper or lower story of the building, according to the warmth or moisture required, the tiny *eggs*, the white legless *larvæ* (maggots), or the *pupæ*, the latter, which are enclosed in a cocoon (see p. 333) being falsely called ant-eggs. They further have to clean the helpless larvæ, and to supply them with

Digitized by Google

drops of liquid food which they vomit forth for this purpose. Finally, they have to bite through the tough cocoon, when the escaping insects burst the pupal skin.

D. Method of obtaining Food.

Another section of the working females go out in search of food, and bring it home when obtained. Their *long and powerful legs* (compare with ground beetles and white cabbage butterfly) facilitate walking, and their *sharply-clawed feet* enable the insects to climb up trees, etc. Here some may be seen dragging a worm along; there others are gnawing away at the body of some dead animal till nothing but the skeleton is left; on the trees a number of them may be seen hunting after all sorts of woodland pests; others, again, are climbing up to their "milch cows," the plant lice or aphides (which see), in order to lap up their sweet excretions, for ants are particularly fond of sweet substances. (The lingua, however, is much shorter than in bees. Why are ants unable to live exclusively on plant juices like lepidopterous insects, or as bees do to a large extent?) During the cold season our native ants are unable to find food or to lay up stores of reserve material (why not?); they accordingly enter upon a stage of *hibernation*.

E. Friends and Messmates of Ants.

In addition to the plant lice, ants have a quite peculiar circle of friends. In their nests we find a number of other insects and their larvæ, which are maintained and protected by them like their own sisters; some, indeed, are actually fed, having, as the result of nurture, lost the power of feeding themselves. What services these boarders render their hosts in return is not known. Possibly they, too, like the aphides, yield up sweet secretions.

F. Enemies.

(*a*) If an ant-hill be struck, its inhabitants rush forth like men from their houses during an earthquake. At the same time we observe a fine spray arising from the ant-heap, which is produced by the insects ejecting from the end of the abdomen a *poisonous fluid* intended to drive off their disturber. If we catch some of this spray in the palm of our hand, we notice that it possesses a strong aromatic smell, which is due to formic acid contained in the fluid. This poison the red ant, which, unlike other species, is unprovided with a sting, endeavours to introduce into the bite which it inflicts with its mandibles. In this operation the great *mobility and suppleness* of its whole body is of great

Digitized by Google

aid to the insect. The first abdominal somite having the form of a thin stalk, the animal is able to approach the tip of the abdomen to the opening of the mouth. (How are these arrangements also of advantage to ants provided with a sting?)

(*b*) *Enemies.*—Woodpeckers, wrynecks and ant-lions consume large numbers of red ants, and also of other species, but their chief enemy is to be found within their own ranks, just as man's chief enemy is man. An eternal war is waged between the separate communities: an ant with the "scent" of an alien nest (see bee; the organs of sense are placed in the elbowed *antennæ*) is at once attacked, killed and devoured. The same treatment is dealt out to the larvæ and pupæ of foreign nests when an opportunity offers itself. (Some species of ants do not devour the captured larvæ and pupæ, but rear from them a band of *helpmates* or *slaves*, whom they compel to work for them. Indeed, some ants can no longer exist without slaves, their mandibles being only adapted for fighting, but no longer for feeding. Some (chiefly foreign) species actually undertake well-ordered slave-raiding expeditions.

G. The Ant in its Relations to Man.

As an industrious destroyer of many noxious insects (pine-moth caterpillars, bark beetles, etc.), the red ant is most useful to man, and we ought therefore not to rób it of its pupæ (used as food for goldfish and cage birds), or drown the insects by thousands in alcohol (formic alcohol). Those species, on the other hand, which attack fruit and grapes or protect the injurious aphides, and pilfer all sorts of sweet delicacies in our houses, must be regarded as destructive or troublesome creatures. Ants render no service in the fertilization of flowers (see bee) on account of their body being *thin and smooth.* Indeed, many plants protect themselves (by what means?) against the visits of these unwelcome pilferers.

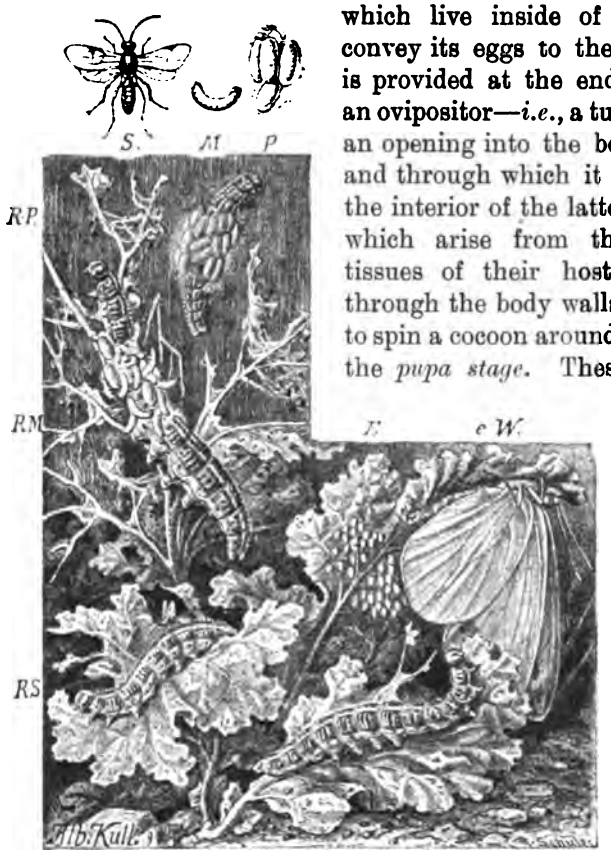
Sub-Order 2: Provided with a Boring Organ (Terebrantia).

Families: Ichneumon Flies (Ichneumonidæ); Gall Flies (Cynipidæ); Saw Flies (Tenthredinidæ) and Wood Wasps (Uroceridæ).

1. Among the caterpillars of the white cabbage butterfly, which ascend planks, walls, etc., to enter into the pupa stage, we always notice some which are dead and surrounded by small yellow egg-like bodies. From each of these supposed "caterpillar's eggs" there escapes in the following spring a black fly about $\frac{1}{3}$ inch long, an **Ichneumon Fly** of the

Digitized by Google

Cabbage Caterpillar (*Microgaster glomeratus*), which had lain concealed as pupa in the so-called "egg." Now, how did the pupa get there? If we visit a cabbage-garden we may, if we are fortunate, see the fly at work. It has settled upon a caterpillar in order to "infect" it with a number of its *eggs;* for the larvæ of the ichneumon fly are *parasites* which live inside of the caterpillar. To convey its eggs to their destination, the fly is provided at the end of its abdomen with an ovipositor—*i.e.*, a tube with which it bores an opening into the body of the caterpillar, and through which it conveys its eggs into the interior of the latter. The white *maggots* which arise from the eggs live on the tissues of their hosts, and finally break through the body walls of the latter in order to spin a cocoon around themselves and enter the *pupa stage*. These pupæ form the so-called caterpillar's eggs. Other species of ichneumon flies deposit their eggs in other insects, in their larvæ, pupæ, or even eggs. Some, with their boring instrument, even bore into wood to the depth of half an inch or more in order to get at the bore-worms in the interior of the trunk. Since any insect once infected by these eggs is doomed to perish, we must regard the ichneumon flies as important helpers in the destruction of numerous insect pests.



CHNEUMON FLY OF CABBAGE CATERPILLAR.

R.S., caterpillar being stung by an ichneumon fly; R.M., caterpillar with maggots bursting forth from its body and entering pupa stage; R.P., caterpillar surrounded by pupæ; S., ichneumon fly; M., maggot; P., pupæ (the last three figures magnified).

2. We are all familiar with the galls of oak-leaves, which are about the size of a cherry and of ruddy colour. If one of these be opened in autumn, a small black fly, the **Oak-gall Fly** (*Cynips quercus folii*) will be found inside, to which the gall owes its origin. While the leaf was

Digitized by Google

still in the bud, a female gall fly, the mother of the present insect, deposited an egg within it. The introduction of this foreign body acted as an irritant, the effect of which was still further increased on the egg producing a white maggot which fed on the juices of the leaf. In consequence of this, the tissues of the leaf around the affected spot proliferated, resulting in the formation of a gall, from which the perfect insect will now soon make its escape by the help of its strong mandibles. If we cut one of these galls in two, the knife will be stained black, owing to the formation of iron tannate—in other words, ink—which results from a chemical combination of iron with the tannic acid of the gall. Hence, formerly these galls were used for the preparation of ink, but the galls most largely used in the production of ink, and tannic and gallic acids, are obtained from *Quercus lusitanica* in Asia Minor, and are formed by the larvæ of *Cynips gallæ-tinctoriæ*. The so-called oak-apples are galls formed on the twigs of the oak by another species of gall-fly.

The rose-galls, commonly occurring on the stalks of the wild rose and looking as if they were covered with moss, owe their origin to the **Rose-gall Fly** (*Rhodites rosæ*). They invariably provide food, shelter and protection to several larvæ.

3. The **Saw Flies** (*Tenthredinidæ*) exhibit the same contrast to their larvæ as lepidopterous insects to their caterpillars; for, whilst the perfect insects suck up sweet honey and pursue other insects, their larvæ feed upon leaves. Hence, it need not surprise us to find in these latter a repetition of the shape and colours of caterpillars. (See white cabbage butterfly. Why are the larvæ of the other Hymenoptera white maggots?) They may, however, be easily distinguished from caterpillars by the larger number of abdominal or pro-legs (generally eight pairs), and also by the peculiar attitude they frequently assume. Thus, they will roll themselves up in a spiral coil, or elevate the posterior part of their body, twisting it into a peculiar shape like a sign of interrogation (?), at the same time moving it rhythmically up and down to frighten off the dangerous ichneumon flies. On account of their resemblance to caterpillars, they have been called "false or pseudo-caterpillars." They are very voracious insects which frequently do much damage to many of our cultivated plants (gooseberry and currant bushes, plum and cherry trees, roses and pine-trees).

4. Still more destructive are the **Wood Wasps** (*Uroceridæ*), the larvæ of which are well known under the name of "bore-worms." The most familiar is the **Giant Sirex** (*Sirex gigas*). Its larva is often introduced into houses with timber, where all of a sudden the perfect insect, conspicuous by its size (up to 1½ inches) and wasp-like markings, makes its appearance.

Digitized by Google

ORDER IV.: TWO-WINGS (DIPTERA).

Mouth parts piercing and suctorial, forming an unsegmented trunk or proboscis; all the thoracic somites coalescent (separate only in the wingless fleas); fore-wings membranous, with few nervures; hind-wings metamorphosed into club-shaped "balancers," or "halteres." Metamorphosis complete.

Sub-Order 1: Flies (Brachycera).

The House Fly (*Musca domestica*).

(Length ¼ to ⅓ inch.)

A. An Inmate of the House.

This insect, as its name implies, is an *inmate of the house*, where, however, no one welcomes its presence. Late in summer, especially when the nights begin to get cool, the flies come into our houses in such quantities as to become a veritable plague. They soil everything, pilfer our food, and annoy and disturb us in our sleep, however often we may chase them away. With the approach of winter most of them die. Their ranks are especially apt to be thinned by a fungoid disease (the insects attacked by it appearing as if covered with mould). Only a few survive the winter to continue the species.

B. Colour.

The ground colour is a dirty gray. On the thorax there are four black stripes; the abdomen is of a chequered black above, pale yellow below.

C. Motion.

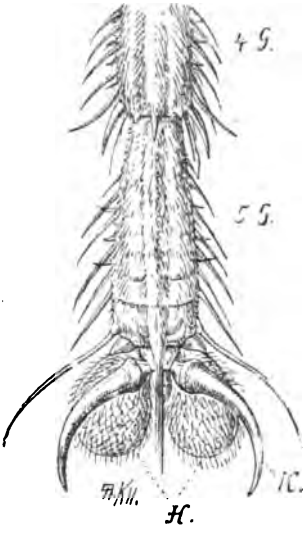
On warm bright days the fly is in constant motion.

(*a*) Its membranous *wings* easily carry it to any spot it fancies. Of the two pairs of wings usually found in insects, only the front pair is fully developed. The hind pair is reduced to two minute structures, each covered with a small cutaneous scale. They are described as "balancers," "poisers," or "halteres," and in appearance are not unlike drumsticks. The *buzzing* noise heard during flight, and the *sound* (voice) which the insect emits, sometimes voluntarily and also when held fast, are produced in the same manner as in the bee (see p. 364, Section 2, *a*).

(*b*) As in all insects which are good fliers (see white cabbage butterfly and honey-bee), all the three *thoracic* somites are coalescent.

Digitized by Google

(*c*) Its long and movable *legs* adapt the fly for rapid running. Its power of settling on and running up smooth window-panes or on the ceiling, in apparent opposition to the law of gravity, is a well-known, but nevertheless very wonderful, phenomenon. It is due to the presence of two finely-haired adhesive pads or balls situated between the two claws of the last tarsal joint, and constantly kept moist by a fluid perspiration. According to some naturalists, this fluid is sticky, so that the insect is glued, as it were, to the supporting surface; according to others, it merely serves to attach the adhesive pads more firmly and securely, just as two glass plates adhere more firmly to each other if a few drops of some liquid be introduced between them.



FOOT OF HOUSE FLY (SEEN FROM ABOVE). (Strongly magnified.)

4.G. and 5.G., Fourth and fifth tarsal joints; K., claw; H., adhesive balls.

Flies, as we must have often observed, also use their legs for cleaning their bodies, which, owing to their habit of frequenting dusty places, must get very dusty. This dust, however, would act very injuriously on the eyes. (Why? We wipe the glasses of our spectacles. How are our eyes kept clean?) Accordingly, we frequently see flies brushing, as it were, their movable heads, their large eyes, their wings, thorax and abdomen, and finally cleaning the legs, *i.e.*, the brushes themselves, by rubbing them against one another. The legs, being *hairy* and very *movable*, are excellently adapted for these operations.

D. Food.

No sooner has a meal been placed on the table, or anything eatable, such as a dish of fruit, some sugar, etc., put out, than the flies also are on the spot.

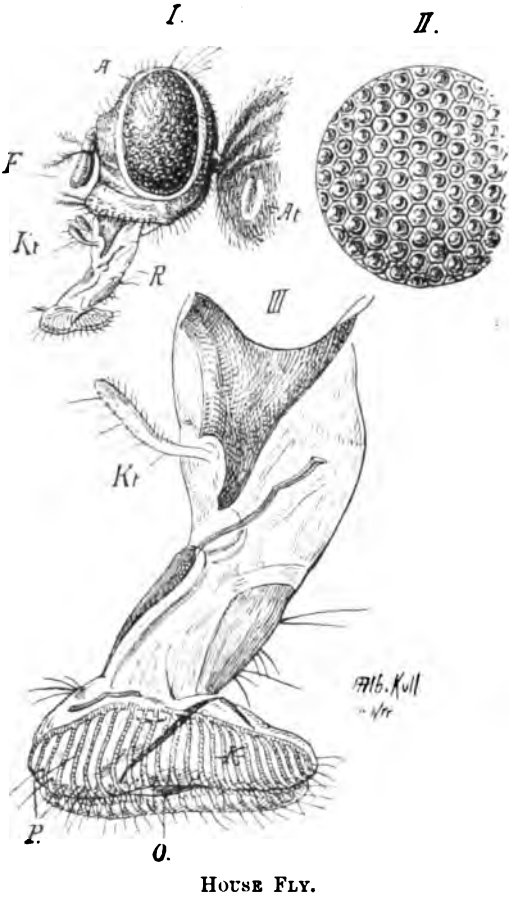
(*a*) We are ignorant as to the means by which the insect so quickly discovers the presence of food. It is impossible to decide whether this discovery is effected by the large hemispherical compound eyes, to which three simple eyes, or ocelli, are further added, or by means of the minute antennæ. All we know is that the fly is there, and at once begins its meal.

(*b*) The *proboscis* is pestle-shaped, and used for sucking up fluids. It is formed from several of the mouth parts, which are so disposed as to form a tube. (In the house fly, the mandibles and maxillæ are reduced to rudiments; the insect is therefore unable to sting like other Diptera;

Digitized by Google

see gnat.) When not in use, the proboscis is retracted to save it from injury. (Compare with bee, butterfly, and bug.)

Though its mouth parts are only adapted for suction (organs of mastication being absent), we nevertheless see flies consuming sugar, bread, and other solid substances. These accordingly must be previously dissolved. For this purpose a saliva is poured forth from the proboscis. However, this saliva, if it were dropped directly upon the solid morsels, would be absorbed by them, and so lost to the fly; to prevent this, the proboscis is dilated at its end into two large *pads* (the head of the pestle), which are traversed by narrow canals. The saliva flows along these canals, and is discharged by narrow clefts upon the surface of the pad, where it forms a layer of such thinness as not to be absorbed by the food morsels. On the other hand, a small portion of the latter is dissolved by the saliva, which is then, together with its dissolved contents, drawn up again through the proboscis. Hence a fly cannot consume food of an insoluble nature.



HOUSE FLY.

I. *Head and Anterior Part of Thorax* (× about fifteen times): At., A spiracle on thorax; F., antennæ; Kt., maxillary palpi; R., proboscis; A., compound eye, at II. more strongly (about thirty times) magnified. III. *Proboscis* (also magnified about thirty times): P., Pad-like swellings of the proboscis traversed by canals (K.); O., opening of proboscis.

E. Development.

(*a*) The fly deposits its small white *eggs* upon all sorts of decaying substances, more especially horse-dung. (This explains the abundance in which this insect occurs in stables and farmhouses.) Only twelve hours later

(*b*) The *larvæ* escape from the eggs. They bore their way down into

Digitized by Google

the nauseous mass and feed to their hearts' content. Their food being on the spot, they are not obliged to move from their place, and are consequently legless creatures or maggots (see larva of bee); moreover, as they live in the dark, they are eyeless and of white colour (see larva of cockchafer).

(*c*) About a fortnight later the larva enters the *pupa* stage. In its passage to this condition it does not, however, cast its larval skin; this merely shrinks somewhat, hardens, and forms a protecting envelope for the pupa, forming a small cask, as it were, in which the pupa rests.

F. Importance in the Economy of Nature.

From the manner in which it feeds, the maggot of the house fly (in common with those of other fly species) rapidly disposes of a quantity of putrefying substances, which would otherwise pollute the air. The fact, too, that the fly itself serves as food for many other animals (name some) teaches us to regard even this despised creature as a by no means unimportant link in the machinery of Nature.

Other Species of Fly.

A host of flies buzz around us on each warm summer day.

Among them, recognisable by its deep humming note and the brilliant blue abdomen, we may note the **Blue-Bottle Fly** (*Musca vomitoria*), which is fond of depositing its eggs ("fly-blows") upon meat and cheese.

The jumping maggots found in cheese are, however, the progeny of another species, viz., the **Cheese Fly** (*Piophila casei*).

The **Grey Flesh Fly** (*Sarcophaga carnaria*) deposits its maggots, which escape from the eggs before they are laid, on meat and dead animals. This ugly creature reaches a length of above ½ inch, and is easily recognised by its reddish head and the grey and black chequered abdomen.

Where dung is deposited, we soon meet with the brilliantly green coloured **Gold Fly** (*Musca cæsar*).

The usually gay-coloured flies often seen hovering over flowers with rapidly vibrating wings belong to the genus *Syrphus*. Their larvæ are mostly green-coloured, and live on leaves. In external shape they are not unlike a leech, and their food consists of green flies or aphides, whose juices they suck.

On flowers also we find the **Drone Fly** (*Eristalis tenax*), which has a deceptive resemblance to a honey-bee. Its larvæ frequent drains, cesspools, puddles, etc., and are known as "rat-tail grubs."

Digitized by Google

The maggots in cherries are the offspring of the **Cherry Fly** (*Trypeta cerasi*), a small insect with brown bands on the wings.

A fly very similar in appearance to the house fly is known as the **Stinging Fly** (*Stomoxys calcitrans*). It annoys men and cattle on warm sultry days by the painful stings (see gnat) which it inflicts, its favourite place for settling on being the calves of the leg.

The **Gad Fly** (*Tabanus bovinus*) and its allies are still more formidable blood-suckers, selecting chiefly cattle for their attacks. Cattle become alarmed on even hearing the hum of this insect, and run about frantic, with their tails in the air.

Neither of these species is to be compared with the **Tsetse Fly** (*Glossina morsitans*) of East Africa, which by its stings spreads a contagion which destroys cattle to such an extent that cattle-rearing becomes impossible in districts where this fly occurs.

In our latitudes also occur a number of flies which are a veritable scourge to cattle.

One of the most formidable is the **Ox Warble Fly** (*Hypoderma bovis*), which somewhat resembles a humble-bee. This fly, as well as another species (*H. lineatum*) which is more common in England, lays its eggs singly in the hair on the backs of cattle. The maggot when hatched burrows into the skin, and causes a large tumour called a warble, in which it lives and grows. The tumour opens to the exterior by a small aperture through which the maggot obtains air. The maggot remains in the tumour for ten or eleven months, when it is full-grown. It ultimately drops to the ground, where its development is completed.

A closely related species is the **Sheep's Nostril Fly** (*Œstrus ovis*), the larva of which lives parasitically in the cavities of the nostril and frontal bones of the sheep.

In the stomach of the horse a disgusting kind of maggot is often found attached by means of oral hooks, like a tape-worm (which see). It is the larva of the **Horse Bot Fly** (*Gastrophilus equi*), which glues its eggs to the hairs of the breast, neck, or fore-legs of horses. In consequence of the resulting irritation the horse licks off these larvæ, which thus find their way into the intestinal canal. When they have reached maturity they leave their host with the fæces.

Sub-Order 2: Gnats (Nematocera).

The Common Gnat (*Culex pipiens*).

(Length about $\frac{1}{8}$ inch.)

The gnat—apart from its long, plume-like *antennæ* and other details of structure—as closely resembles the house fly as two members of the

Digitized by Google

same order can resemble each other. (Describe the insect.) The *female* is a "blood-sucking" creature; the male, since it does not lay eggs, and therefore does not require so nutritious a food, is satisfied with the sweet juices of plants. An insect living on blood must, however, possess instruments for tapping this special juice. These are formed by the two mandibles and maxillæ, which are transformed into small daggers (to which is added a fifth bristle formed from a prolongation of the labium). These parts lie within the proboscis, which (exactly as in the house fly) is formed by the long, gutter-shaped labium and the labrum roofing in the gutter above. After pressing the proboscis against the skin of its victim, it pushes in the daggers and at once begins to suck the blood from the wound. (The mouth parts of the blood-sucking fly species are essentially constructed on the same plan. How does the bee sting, on the other hand? Ammonia alleviates the bite of gnats.)

MOUTH PARTS OF FEMALE GNAT.
(Enlarged fifteen times.)
K., Pronotum; Ol., labrum; Ok., mandibles; Uk., maxillæ; Kt., maxillary palpi; Ul., labium, with its process (F.).

Gnats are most numerous in well-watered districts, their youth being passed in ponds and pools. The *larvæ* are legless creatures, provided on their sides with long, swimming hairs, and progressing by undulatory movements of the body. They are mostly seen hanging to the surface of the water, and at the same time spreading out a star or rosette of fine waterproof hairs. In the middle of this rosette lies the opening of the respiratory tube, which is capable of being closed; hence these creatures breathe the air outside of the water. (Compare with larvæ of water beetle.)

The *pupæ* also live in the water. They are mostly seen with their body bent into the shape of a sign of interrogation (?), hanging to the surface of the water by two horn- or ear-like appendages of the head, in which the respiratory tubes terminate. Thus, in consequence of the position of these appendages, the head is directed upwards. At the slightest shock or disturbance they sink below the surface. They swim by the help of their long, movable abdomen, which is sharply marked off from the thick, anterior portion (head and thorax) of the body. In no other insect family do we find *pupæ* endowed with so much mobility and (in connection therewith) of such shape. In the case of the gnats, however, these peculiarities are indispensable owing to their free existence in the water, where they are exposed to all sorts of dangers. Unless they were active creatures, they would soon succumb to their numerous enemies. (Observe the development of the gnat in an aquarium.)

Digitized by Google

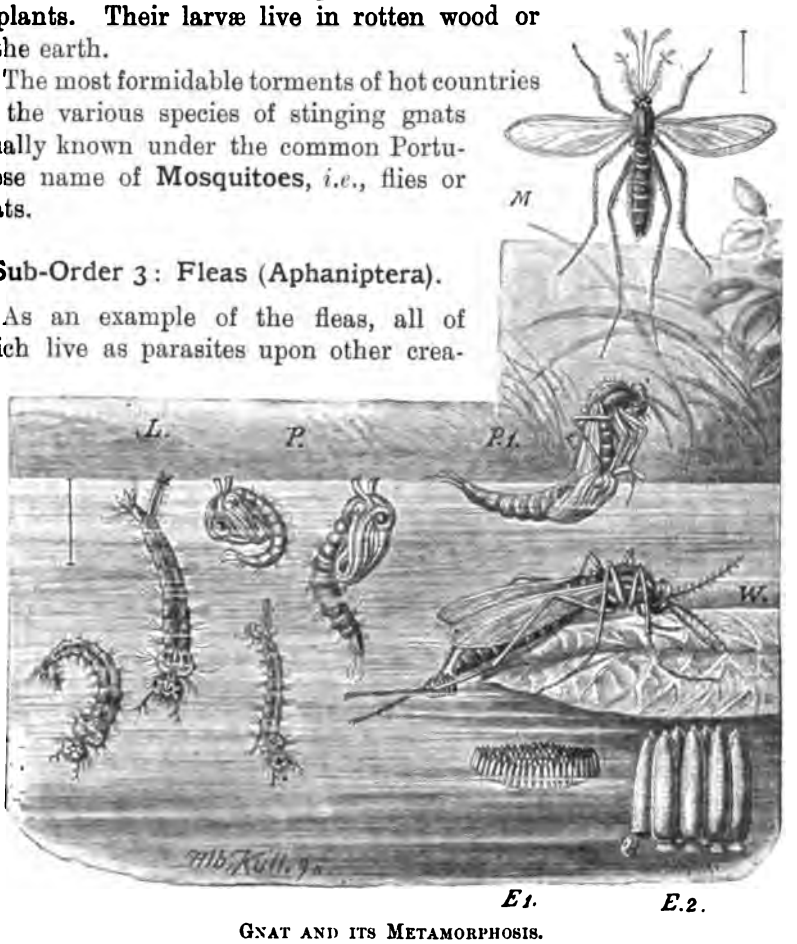
Allied Species.

The **Crane Flies** or **Daddy Long-legs** (*Tipula*) are noticeable for their long legs, which drop off if the insects are only lightly touched. These creatures do not sting (proboscis very short), but live on the juices of plants. Their larvæ live in rotten wood or in the earth.

The most formidable torments of hot countries are the various species of stinging gnats usually known under the common Portuguese name of **Mosquitoes**, *i.e.*, flies or gnats.

Sub-Order 3: Fleas (Aphaniptera).

As an example of the fleas, all of which live as parasites upon other creatures, we shall mention the **Human Flea** (*Pulex irritans*). As in all blood-sucking insects, its *mouth parts* are both piercing and suctorial (see gnat). Being wingless, all the somites of the thorax may be separate.



GNAT AND ITS METAMORPHOSIS.

M., Male (the adjoining line indicates the natural size); W., female depositing eggs; E.1., egg cluster (somewhat magnified); E.2., a few of the eggs (more strongly magnified)—from one of the eggs the larva has already escaped, and its lid is therefore burst open; L., larvæ (the line indicates their natural size); P., pupæ; out of pupa, P.1., a perfect insect is shown escaping.

Digitized by Google

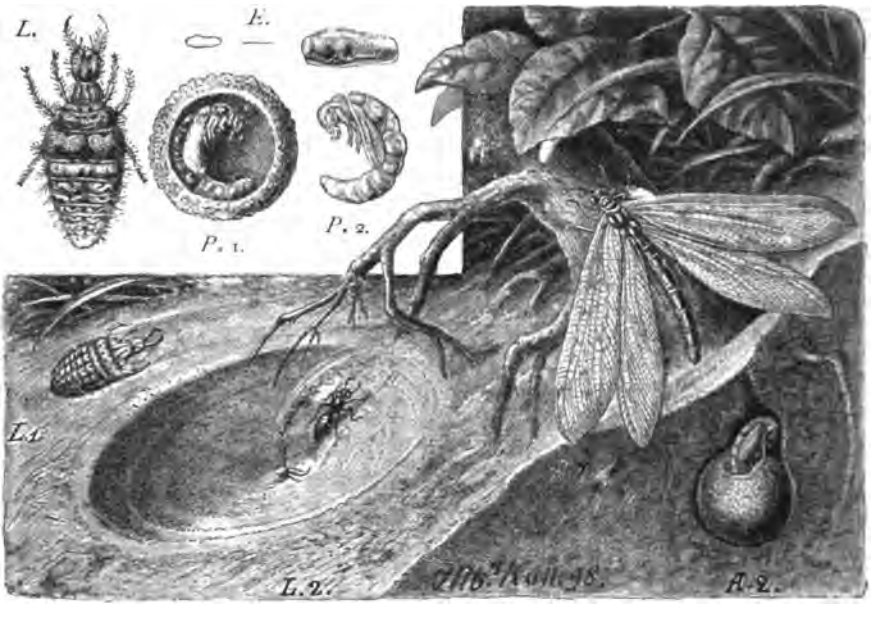
To compensate for the want of wings, the *hind-legs* form long and powerful jumping organs, which enable the small brown wight to execute enormous leaps. The *eggs* are deposited in the chinks of floor-boards, rotten wood, etc. The decaying vegetable and animal substances found in such places form the food of the legless *larvæ*, which here also pass through their pupa condition.

ORDER V.: NET-WINGS (NEUROPTERA).

MOUTH parts masticatory; the first thoracic somite (prothorax) usually free; wings all equal, transparent, with reticulate neuration (name). Metamorphosis complete.

The Ant-Lion (*Myrmeleon formicarius*).

(Length up to 2 inches.)



ANT-LION AND ITS METAMORPHOSIS.

E., Egg: on the left, natural size; on the right, magnified; L., larva (magnified about four times); L.1., larva (× about twice) commencing to build a funnel; L.2., larva buried at bottom of funnel, and bombarding an ant with sand; P.1., pupa with cocoon opened; P.2., pupa removed from cocoon; A.1., ant-lion sitting on a tree-trunk; A.2., ant-lion breaking through cocoon after escaping from pupa.

On sandy soil, especially at the edges of pine-woods, we often come across pretty funnel-shaped depressions, at the bottom of which is found

Digitized by Google

a small, stout larva which goes by the name of an *ant-lion*. Even if the creature had not burrowed down into the sand with its mandibles, we should scarcely be able to distinguish it owing to its *sandy colour* (protection). It is fully entitled to its peculiar name, being engaged early and late in catching ants; though any other small insect is equally acceptable as food. How can so stout a creature, which, moreover, only *runs backwards*, succeed in capturing a fleet-footed ant? It could certainly not do so by merely chasing it, but for this purpose makes use of the funnel at the bottom of which we discovered it. Thus, if an ant happens perchance to come to the edge of this trap, the loose sand glides away under its feet and the insect slips down the slope with it. Forthwith the robber, lurking in ambush, begins to bombard the falling victim with sand, which, in rolling down, drags it deeper and deeper down into the funnel. In this operation (as well as in building the funnel) the larva employs its *broad* head, which has a trough-shaped depression above, as a round shovel. In this manner the victim gets into the "lion's jaws," *i.e.*, between the powerful mandibles, which seize it, bore it through, and suck it dry; for its destroyer is devoid of a mouth (see larva of the water beetle).

For the purpose of *entering the pupa stage*, the larva buries itself deep in the sand and spins a cocoon of web and sand, which it leaves a short time afterwards as a light-winged *ant-lion*. The perfect insect bears a strong resemblance to a dragon fly (which see), but is easily distinguished from the latter by the club-shaped antennæ and the brown-spotted wings, which during rest slope downwards from the body.

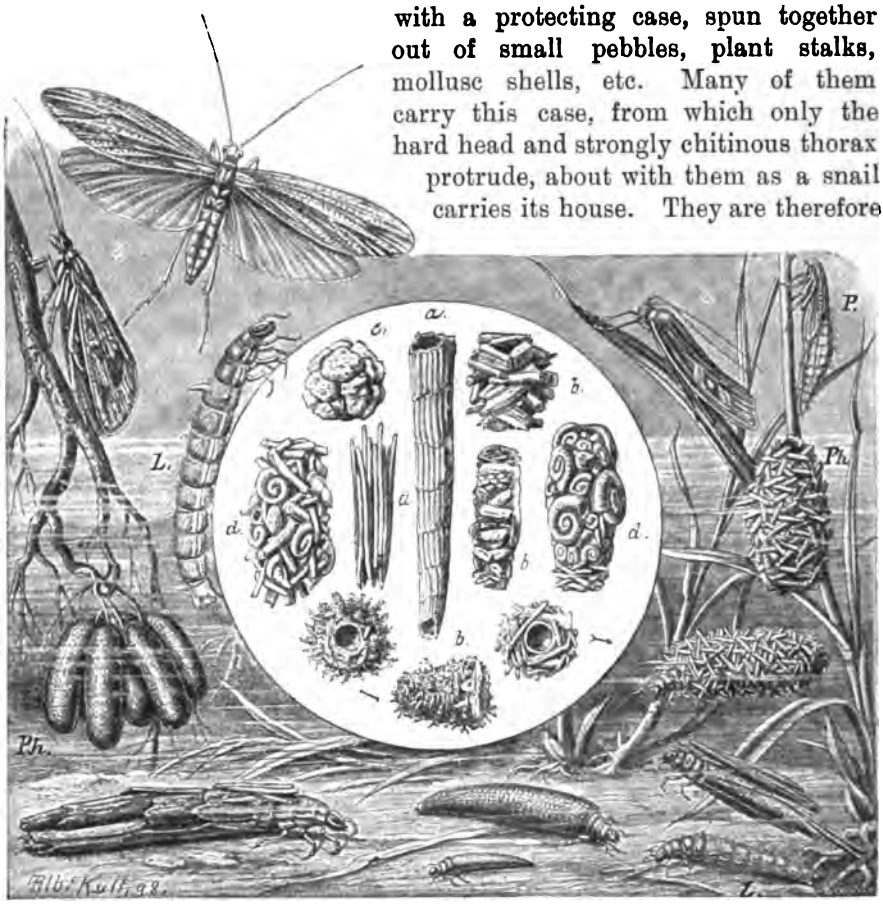
Allied Species.

Upon leaves may frequently be seen white threads having a small knob at their ends. These are stalked insect eggs. They give rise to green larvæ, which make great havoc among the plant lice. They are on this account called aphis lions, and strongly resemble the larvæ of the lady-bird (which see). The perfect insect is the delicate **Aphis Lion** (*Chrysopa perla*), which takes up its winter quarters in dwelling-rooms, and is easily recognised by its delicate, gauze-like green wings and its brilliant golden-coloured eyes ("golden-eye").

The **Caddis Flies** (*Phryganeidæ*) are neuropterous insects with finely scaled or hairy wings. Their aquatic larvæ, or "caddis-worms," are much better known than the perfect insects. Their abdomen being very soft (compare with hermit crab), the larvæ surround themselves

Digitized by Google

with a protecting case, spun together out of small pebbles, plant stalks, mollusc shells, etc. Many of them carry this case, from which only the hard head and strongly chitinous thorax protrude, about with them as a snail carries its house. They are therefore



CADDIS FLIES AND THEIR METAMORPHOSIS.

In Centre: Empty cases; composed of: vegetable bodies disposed—*a.*, longitudinally, *b.*, transversely; *c.*, small pebbles; *d.*, shells of molluscs (slightly less than natural size). *In and above the Water:* Larvæ of different species in cases composed of different substances; L., two larvæ removed from their cases; Ph., pupa cases (those on the left hanging to the root of a tree); P., pupa which, having crept out of its case, is about to cast its skin and develop into the perfect insect. *Above the Water:* Three fully developed insects of different species.

slowly moving creatures, which live on decaying refuse matters. They breathe by tracheal gills, visible externally in the form of fine threads.

Digitized by Google

ORDER VI.: LONG-BEAKS (RHYNCHOTA).

MOUTH parts piercing and suctorial, forming a jointed proboscis or beak; first thoracic somite (prothorax) free; the two pairs of wings similar or dissimilar in form. Metamorphosis incomplete.

Sub-Order 1: Bugs (Heteroptera).

The Bed Bug (*Cimex lectularius*).

(Length ⅛ to ¼ inch.)

The bed bug is one of the most disagreeable of *human parasites*. In the daytime it lies in hiding, finding, by reason of its *thin flattened* body, which is of *brown* colour, easy accommodation in all sorts of chinks and crevices. At night, however, it emerges from its hiding-place in order to suck the blood of sleepers. Its mouth parts, which together form a jointed proboscis or beak (hence name of order; *rhynchos* = a beak), are accordingly well adapted (like those of the gnat, which see) for piercing as well as sucking. During rest the proboscis is laid back in a groove along the under side of the body, to protect it against injury. A poisonous *saliva* which enters the wound produces inflammation and swelling of the affected part. The *wings* of the bug are mere *rudiments*, and the insect is therefore incapable of flight. The disgusting smell emitted by this insect and many other bug species serves it as a means of protection against enemies. The *young*, like the mature insects, feed upon blood. Hence the metamorphosis is accomplished gradually after several moultings of the skin without the interposition of a pupa stage (see grasshopper, p. 394). Owing to its great *fecundity*, this obnoxious blood-sucking pest multiplies so rapidly that only by the utmost cleanliness can it be got rid of from dwellings where it has once established itself.

Allied Species.

A large number of bug species live in the open air. All of these feed upon the juices of plants or animals, which they obtain and suck up by the aid of their "beak." Only a few are entirely or partially wingless. The fore-wings, between which is interposed the frequently large scutellum (see cockchafer), serve as covers for the membranous folded hind-wings (hence name *Heteroptera* = unlike winged). Only the anterior basal half of the fore-wings, however, is hard and coriaceous. Both wings (as in beetles) are folded closely to the body.

The most familiar species is undoubtedly the blackish-red **Scarlet Bug** (*Pyrrhocoris apterus*), called by children "Frenchmen" or

Digitized by Google

"soldiers." It is chiefly met with on lime-trees, and in the absence of hind-wings is incapable of flight.

The **Berry Bug** (*Carpocoris baccarum*) is about ⅜ inch long, brown in colour, and imparts to cherries or other berries at which it sucks the peculiar repulsive, bug-like taste.

The water bugs are active creatures, of decidedly predaceous habits, and most of them capable of inflicting irritating stings. One of them has the peculiar habit of swimming on its back, and is therefore called the **Boat Fly** or **Water Boatman** (*Notonecta glauca*). We accordingly find that its back is light-coloured, while the ventral surface is dark-coloured, exactly the opposite of what we find in other aquatic animals

BERRY BUG ON RASPBERRY BUSH.

Above it, an insect with the wings of the left side expanded. H., Pronotum; S., scutellum; D., coriaceous portion of fore-wing.

(frog, carp, etc.). The body is shaped like a small boat, the back being raised into a kind of keel, while the hind-legs are very long, and transformed into swimming-legs or oars (see water beetle).

In another species the fore-legs have the form of prehensile organs (see praying mantis, p. 396), giving the predaceous creature almost the appearance of a *scorpion* (which see), whence it also obtains the name **Water Scorpion** (*Nepa cinerea*).

On the surface of the water elongated insects may often be seen hopping or gliding along like skaters. These are the **Water-Measurers**

Digitized by Google

(*Hydrometra*). Their long, widely-extended legs supply them with the necessary surface of support.

Sub-Order 2: Homoptera.

On the delicate stalks of meadow and other plants we often find lumps of white froth looking like saliva, and supposed, like many other strange things, to be due to the cuckoo ("cuckoo-spit"). Within these balls we find a small green larva, which has inserted its beak (see bug) deep into the stalk of the plant, on the juices of which it feeds. This juice, after being deprived of its nutritious material, is again exuded from the body of the larva, forming the above-mentioned froth, which now envelops the larva, protecting it against birds and rapacious insects. After shedding its skin several times, the larva passes into the perfect insect, known as the **Frog-Hopper** (*Aphrophora spumaria*). It is a small gray insect, about ¼ inch long, with four similarly constructed wings (homopterous), and not unlike a small grasshopper. It lives on bushes.

In Southern countries, where homopterous insects abound, there are many species the males of which (see grasshopper) emit a loud musical sound. One of these insects, the **Manna Cicada** (*Cicada orni*), is about the size of our grasshopper. It sucks the sap of the manna-ash and other trees. The juices flowing from the wounds, after the insect has satisfied its appetite, harden, and furnish the "manna" of commerce.

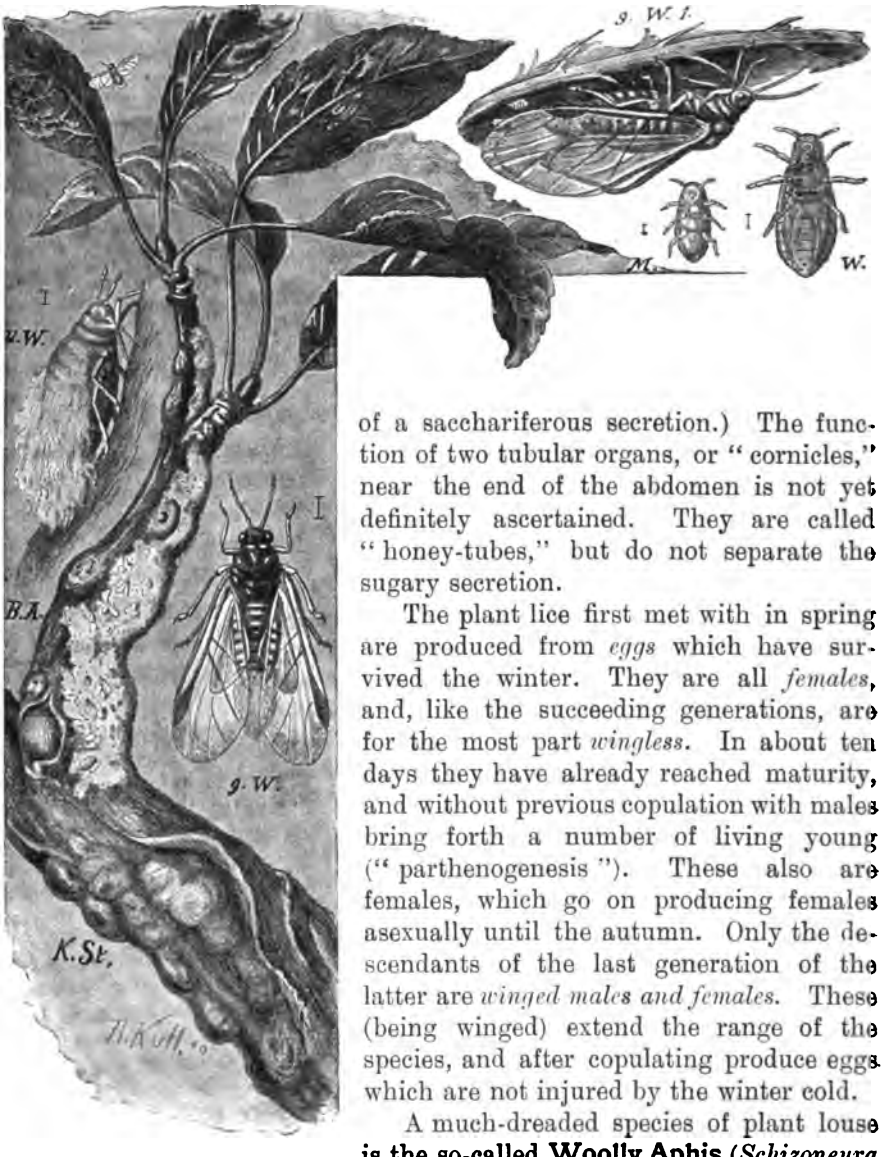
Sub-Order 3: Plant Lice (Phytophthires).

Family 1: Green Flies (Aphidæ).

There is scarcely a plant which, either during spring or summer, entirely escapes the ravages of the **Green Fly** (*Aphis*). Young, and hence soft and juicy, leaves and shoots are often completely covered with these pestiferous insects. Here they lie anchored to the plant, as it were, by their deeply-inserted beaks, withdrawing from it the nutritive juices to such an extent that the parts affected are crippled and die off, and frequently the entire plant is destroyed. The absorbed plant-juices pass rapidly through the bodies of the insects, and are again excreted (see ants) in a semi-digested condition in the form of small drops very rich in sugar, which are thrown off with the help of the hind-legs. In cases where a tree is infested by many thousands of the insects, these drops during dry weather (why only then?) cover the leaves like a varnish, in which case people talk of a "fall of honeydew." (Honeydew may, how-

Digitized by Google

ever, also be produced on leaves as a diseased condition in the form



APPLE BARK PLANT LOUSE, OR WOOLLY APHIS (AMERICAN BLIGHT). Colony of insects on an apple-tree, with different "forms" produced in course of year.

(Letters explained in text.)

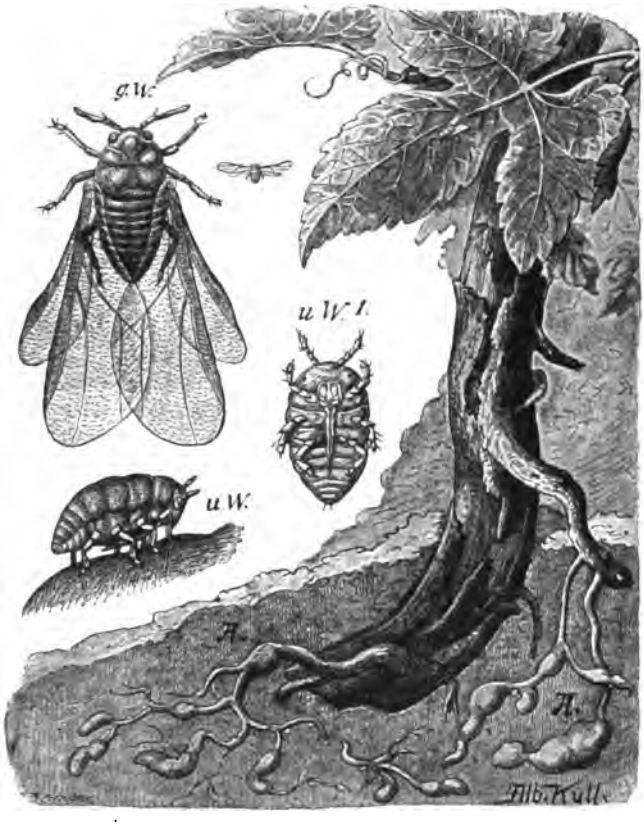
of a sacchariferous secretion.) The function of two tubular organs, or "cornicles," near the end of the abdomen is not yet definitely ascertained. They are called "honey-tubes," but do not separate the sugary secretion.

The plant lice first met with in spring are produced from *eggs* which have survived the winter. They are all *females*, and, like the succeeding generations, are for the most part *wingless*. In about ten days they have already reached maturity, and without previous copulation with males bring forth a number of living young ("parthenogenesis"). These also are females, which go on producing females asexually until the autumn. Only the descendants of the last generation of the latter are *winged males and females*. These (being winged) extend the range of the species, and after copulating produce eggs which are not injured by the winter cold.

A much-dreaded species of plant louse is the so-called **Woolly Aphis** (*Schizoneura lanigera*), which when crushed leaves a red, blood-like stain, hence called "blood-louse" in Germany. It lives on the bark of the apple-tree, and by sucking the sap produces

Digitized by Google

diseased spots (K.St.), which are followed by the slow decay of the tree. The colonies of this plant louse (B.A.) are invariably enveloped in a white, waxy, wool-like substance secreted from the abdominal somites (u.W.), and protecting the insects from enemies. (Compare with frog-hopper.) From eight to eleven generations of wingless females (u.W.) are suc-



VINE APHIS.

A., Swellings at root of vine (natural size); u.W. and u.W.1., wingless females viewed sideways and from below (strongly magnified); u.W., shown sucking at the root; below the body the sheath of the sucking proboscis (inserted into the root); in u.W.1. the proboscis is contained within its sheath; g.W., winged female (strongly magnified); next to it the same insect about natural size.

ceeded in late summer by winged females (g.W.). These spread themselves abroad, and produce on the under side of leaves (g.W.1.) wingless males and females (M. and W.). Each of the latter lays a "winter egg" (in the female [W.] shown in the illustration the egg is discernible

Digitized by Google

through the body wall), from which in the autumn or the succeeding spring one of the early unwinged females (u.W.) is produced.

A far more destructive species is the **Vine Aphis** (*Phylloxera vastatrix*). This insect originates from America, but is continuing to spread over Europe, and in many districts has almost totally ruined the vine culture. The reproduction of this injurious insect is very complicated. From the winter eggs are produced wingless females (u.W.); these produce a number of eggs, which again give rise to wingless females. This process is repeated from six to eight times in the course of the summer. The large number of plant lice produced in this manner suck at the fine root fibres of the vine, producing swellings, A., and so disturbing the functions of the root as to bring about the final destruction of the plant. Among these "root lice," winged individuals (g.W.) are also produced, which leave the soil and fly to other vines, on which they deposit a few very large eggs. These latter give rise to wingless males and females. The latter each lay a single egg, which is one of the "winter eggs" referred to above. Unfortunately, no means have hitherto been discovered of destroying this pest without at the same time ruining the vines.

Family 2: Scale Insects (Coccidæ).

Upon vines, stone-fruit trees and greenhouse plants, we often meet with shield-shaped brown structures which one would hardly suspect to be of animal nature. They are the females of **Scale Insects** which have inserted their beaks into the plant. These insects die in this position, and then serve as a protecting roof to their eggs, which are found beneath them in the form of a white powder. The males have somewhat the shape of an aphis, and are winged and active creatures (why is it necessary that they should be such?).

The **Cochineal Insect** (*Coccus cacti*), which lives on various cactus plants, furnishes, when dried, the valuable red pigment known as cochineal or carmine. It is a native of Mexico, but has for many years been cultivated in Algiers, the Canary Islands, and other localities.

The **Lac Insect** (*C. lacca*) of India, by puncturing fig-trees, produces the flow of a resinous juice from which shellac is obtained.

Sub-Order 4: Wingless Rhynchota or Lice (Aptera).

The members of this group are wingless parasites. The **Lice** (*Pediculidæ*) are blood-suckers furnished with an (introvertible) pro-

Digitized by Google

boscis. Their last tarsal joints are modified into large hooks, by which the parasite attaches itself to the hairs of its host.

The **Head Louse** (*Pediculus capitis*) lives on the heads of dirty people, gluing its eggs (nits) on to the hair.

The **Clothes Louse** (*P. vestimenti*), on the other hand, deposits its eggs between the seams of garments, and sucks blood from the less hairy parts of the body.

The **Dog Lice** (*Trichodectes*), which consume the hairs of dogs and other mammals, and the **Bird Lice** (*Philopterus*), which feed on the barbs of birds' feathers, are also classed with this division, although, on account of the hard nature of their food, their mouth parts are adapted for biting (masticatory).

ORDER VII.: STRAIGHT-WINGS (ORTHOPTERA).

MOUTH parts masticatory; first thoracic segment (prothorax) free; fore-wings forming wing-covers, hind-wings membranous, folded longitudinally in fan fashion. Metamorphosis incomplete.

Group 1: Leaping Orthoptera (Saltatoria).

The Great Green Grasshopper (*Locusta viridissima*).

(Length about 1¼ inches.)

A loud and many-voiced concert resounds in autumn on fields and meadows. The musicians are insects, among which the grasshoppers take a specially prominent place. (Name other musical insects.) The loud "tchick-tchick" resounding from yonder turnip-field, or from the bushes and trees which skirt the field, is the "song" of a grasshopper species—the green grasshopper, with which everyone is familiar.

A. Colour.

Let us very carefully approach our songster, so that it may not observe us. This, however, is easier said than done, for, though we hear it, we cannot discover its exact whereabouts. Nor at last, when we have sighted the creature, do we wonder at having had to search so long; for its *grass-green* colour completely hides it among the leaves which form its favourite resort (hence called *green grasshopper*). This green colour is of twofold use to the insects, serving both as a protection against enemies and as a means of hiding its presence from its prey (see Section C).

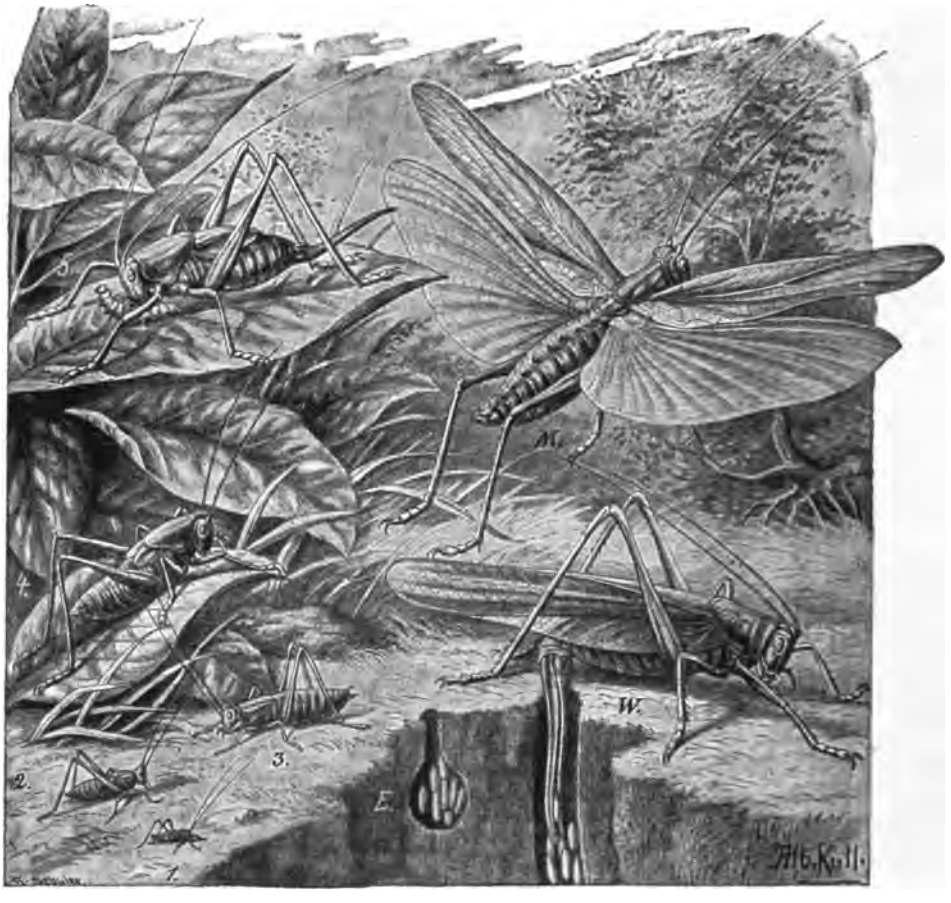
Digitized by Google

B. Locomotion.

Unless seized very rapidly, the grasshopper escapes our grasp.

(*a*) By means of its hind-legs, which are distinguished by their great length and the thickness of the femurs, the insect can execute powerful leaps. (Compare with other saltatorial animals.)

(*b*) For longer journeys, however, the insect makes use of its long



GREEN GRASSHOPPER. Natural size.)

M., Male; W., female depositing eggs in the earth; at E. a little heap of eggs; 1 to 5, larvæ in different stages of development.

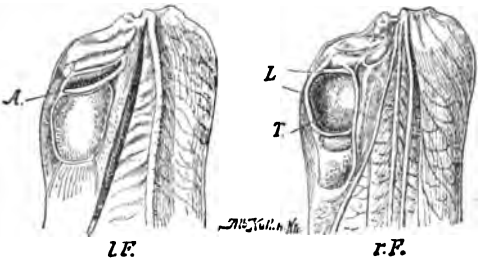
wings, the posterior pair of which only are employed as organs of flight. During rest they are folded together like a fan beneath the narrow fore-wings, which meet like the roof of a house, and, as in beetles (see cockchafer), serve as wing-covers, or elytra.

Digitized by Google

(*c*) These wing-covers, however, are much thinner than in beetles, and lie less close to the abdomen; consequently we find that the *dorsal portions of the abdominal somites* are of much harder consistency than is the case in beetles.

C. Food.

In order to observe the structure and habits of the grasshoppers, it is advisable to take home some of these insects and confine them in a large glass. They are found to consume not only leaves, but also all sorts of insects which are offered them (flies, caterpillars, etc.), and even their fellows of their own species (cannibals). Accordingly, we find their *mouth parts* adapted, as in beetles (see illustration, p. 341), for *biting* (*masticatory*). The head in shape somewhat resembles that of a horse, this resemblance being still further emphasized by the long antennæ, which look like the horse's reins.



SOUND APPARATUS OF GREEN GRASSHOPPER ON ANTERIOR PORTIONS OF WING-COVERS.

(Magnified about five times.)

l.F., Left wing-cover, seen from below; r.F., right wing-cover, seen from above. The other letters are explained in the text.

D. Music.

If we examine our captured specimens, we notice that in some (females) the end of the thick abdomen is provided with a long sabre-like appendage (ovipositor, see Section E) which is absent in other specimens (males). With a little attention we shall easily discover that the latter only are the musicians, and that the sounds they utter are produced by the base of the left wing-cover being rapidly drawn across the base of the right subjacent wing-cover, just as a bow is drawn across the strings of a fiddle. A closer examination reveals the fact that these portions of the wing-covers in the males possess structures which are absent in the females. On the under side of the left wing-case we observe a strong transverse vein (A.), which under the microscope appears to be finely grooved like a file, while on the right wing-cover we notice a very fine, nearly circular spot (T.), bordered above by thick raised edges (L.), so that the whole structure may be compared to a tambourine. The vein or nerve of the left wing-cover being drawn across this raised border causes the tambourine-like instrument to give forth a sound, a means employed by the male for attracting the "silent" females. (Compare with the song of birds.) Naturally, these notes

Digitized by Google

must be heard by the insect which produces them, or by those they are intended to allure. The *auditory organ* of the grasshopper, however, is not placed in the head, but on the swollen portion of the tibiæ of the first pair of legs, each of which has a small cleft on each side of it.

E. Reproduction.

Towards the end of summer the females, which, as already mentioned, are recognisable by their long ovipositors, by means of these instruments deposit their long, narrow *eggs* in the earth, where these delicate structures are safer from enemies than they would be if left exposed. The purely protective purpose of this mode of depositing the eggs is shown by the fact that the *larvæ* do not remain underground, but leave the soil as soon as they escape from the eggs in the following spring. These larvæ resemble their parents in structure and mode of life from the first day of their birth, wings and ovipositors alone being as yet absent. With increasing growth, and after several moultings (see p. 310), these organs also appear, at first as mere rudiments, but after the last moult in their full proportions.

Thus the larva by degrees passes into the perfect insect *without the interposition of a pupal stage.* This phenomenon becomes comprehensible when we consider that both larva and pupa lead a similar kind of life, eat the same kind of food, and inhabit the same locality, and if we pay attention to what was observed when we discussed the quiescent pupal condition of lepidopterous insects (see p. 322, Section 4).

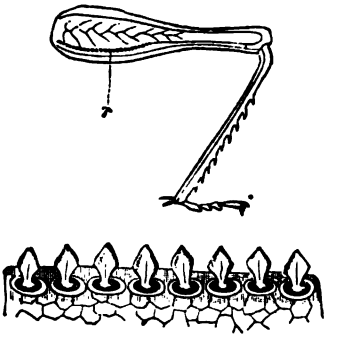
Other Species of Saltatorial Orthoptera.

The allies of the green grasshopper—**Family 1: Grasshoppers (Locustidæ)**—like the latter, live chiefly in bushes and woods, and wear a green-coloured dress. Those, on the other hand, which frequent meadows, fields, hillsides, and heaths—**Family 2: True Locusts (Acrididæ)**—are of gray or brown colour, which protects them as effectively amid their surroundings as the green does their relatives among the leaves. (Compare with frog.) The only parts of the body which are ever of bright colours are the hind-wings, which are covered during rest—an interesting point of agreement with lepidopterous insects (see p. 329). The males in this division also are indefatigable musicians, their wing-covers forming the fiddle, and the femurs of the hind-legs, which on their inner side carry a longitudinal row of very fine chitinous teeth, representing the bow. On drawing these teeth along one of the prominent nervures of the wing-covers, the latter are thrown into sonorous vibrations. The organ of hearing is visible on

Digitized by Google

the sides of the first abdominal somite in the form of a small tympaniform membrane.

The destructive effects of locusts when appearing in swarms is well illustrated in the case of the **Migratory Locust** (*Pachytylus migratorius*), which is a native of Western Asia and Southern Europe. During favourable weather these insects multiply to an enormous extent; this leads to scarcity of food, and they are therefore forced to migrate (hence the name) in order to find fresh pastures. Gathering in immeasurable hordes, they wander forth, obscuring the sun, covering the country where they alight far and wide, and in the briefest time consuming every bit of green herbage. In Southern Russia and Turkey such swarms are not a rare phenomenon, but they have also on several occasions spread their devastations over Central Europe. Allied species frequently make similar havoc in Asia, Africa, and America.



HIND-LEG OF FIELD LOCUST (*Stenobothrus pratorum*).

r., Row of chitinous teeth on the inner side of the femur. *Below:* Some of the teeth, strongly magnified. (After Landois.)

The **third family** of saltatorial Orthoptera consists of nocturnal insects living in concealment, and therefore of dark colour. They are the **Crickets** (**Gryllidæ**), several of which are capable of burrowing.

The **Mole Cricket** (*Gryllotalpa vulgaris*), as its name implies, represents the mole among insects. Like the latter, it digs out subterranean passages, and also possesses a cylindrical body, supported on short legs, the broad fore-limbs being modified into digging spades. Since large muscles are required to put these digging instruments into operation, their thickness and the extraordinary size of the first thoracic somite becomes intelligible. The mole cricket deposits its numerous eggs in holes underground, and then, in order that the sun may more effectively warm the soil and consequently the eggs, the insect bites off the roots of the plants growing above them, which consequently perish. But for this one failing, the mole cricket would be considered among useful animals, since its chief food consists of cockchafer grubs, and other insect larvæ and worms. It is easily got rid of by placing flower-pots in its runs in such a manner that the insect is forced to drop into them.

The thick-headed black **Field Cricket** (*Gryllus campestris*) inhabits small holes, which it digs out for itself. The males of this species are the untiring musicians of fields and heaths.

The **House Cricket** (*Gryllus domesticus*) is a very similar insect, but

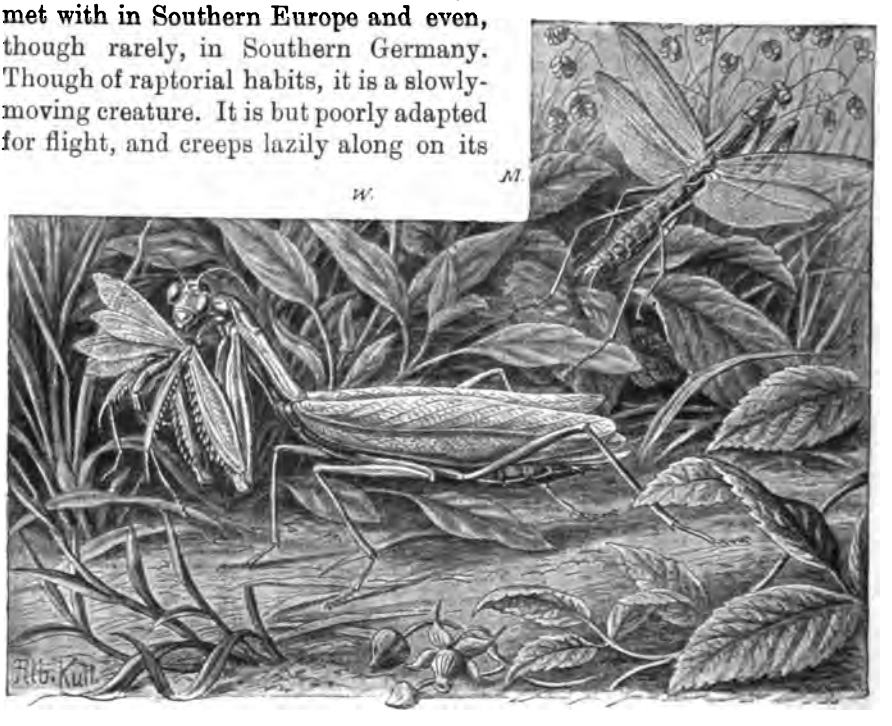
Digitized by Google

of leathery-brown colour. It likes warmth, and therefore is fond of taking up its quarters in bakehouses, kitchens, mills, etc. Flour and all kinds of domestic refuse form the food of this familiar insect. According to popular superstition, the sound of the cricket, like that of several other animals (give examples), forebodes the death of the hearer.

Group 2: Gressorial Orthoptera (Gressoria).

Family 4: Praying Insects (Mantidæ).

The **Praying Mantis** (*Mantis religiosa*) is a fantastic-looking insect, met with in Southern Europe and even, though rarely, in Southern Germany. Though of raptorial habits, it is a slowly-moving creature. It is but poorly adapted for flight, and creeps lazily along on its



PRAYING MANTIS. (Natural size.)
W., Female, which has seized a prey; M., a flying male.

remarkably long middle and hind legs (*gressorial legs*); hence it has to capture its food in a different fashion. Motionless the insect sits in the grass, where, on account of its green colour, it can only with difficulty be recognised (protective and deceptive colouring). The *head* is small, but held loftily erect by the *first thoracic somite* (prothorax), which has the form of a long neck, so that the robber's field of vision is very extensive; at the same time the *fore-legs* are raised, apparently as in

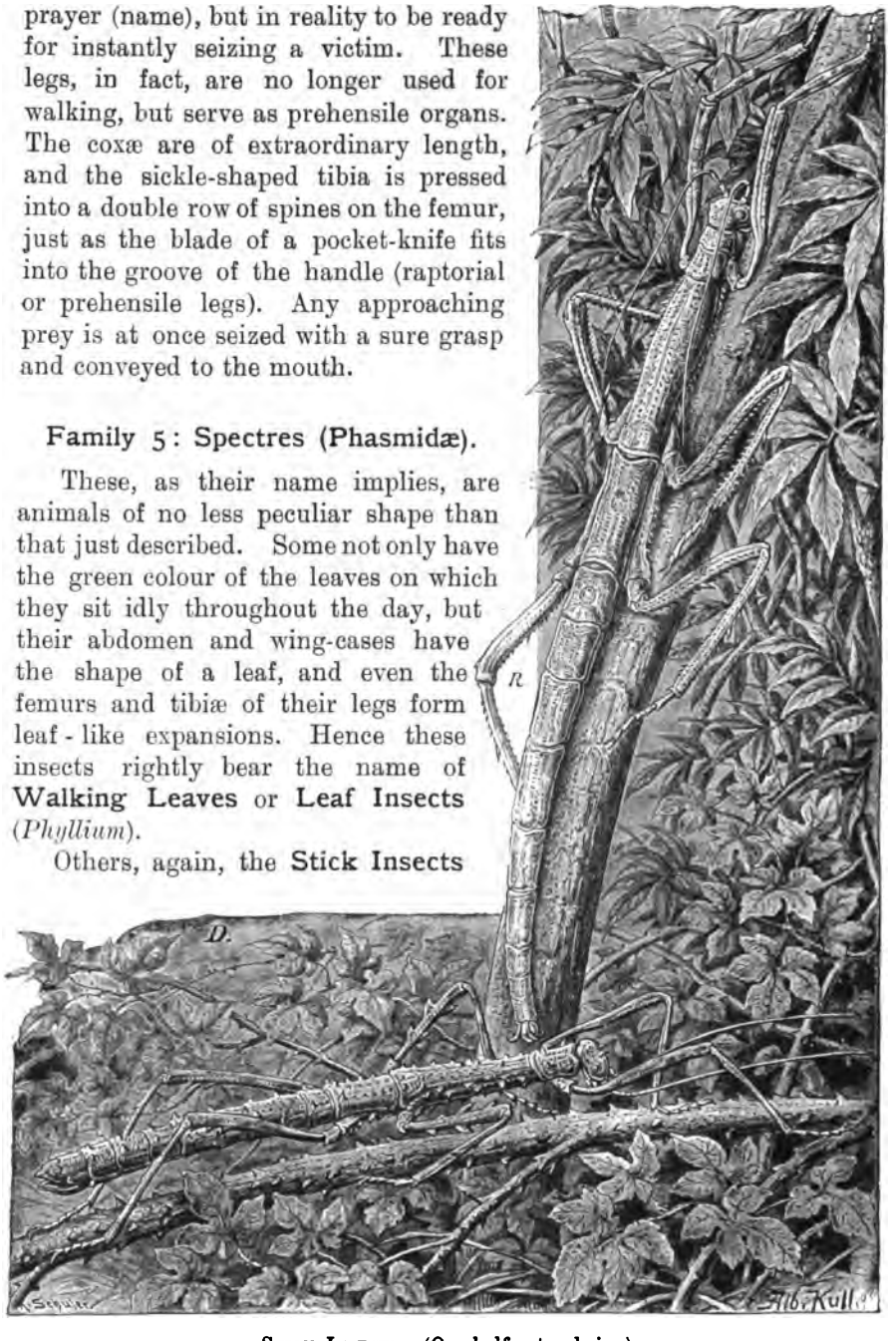
Digitized by Google

prayer (name), but in reality to be ready for instantly seizing a victim. These legs, in fact, are no longer used for walking, but serve as prehensile organs. The coxæ are of extraordinary length, and the sickle-shaped tibia is pressed into a double row of spines on the femur, just as the blade of a pocket-knife fits into the groove of the handle (raptorial or prehensile legs). Any approaching prey is at once seized with a sure grasp and conveyed to the mouth.

Family 5: Spectres (Phasmidæ).

These, as their name implies, are animals of no less peculiar shape than that just described. Some not only have the green colour of the leaves on which they sit idly throughout the day, but their abdomen and wing-cases have the shape of a leaf, and even the femurs and tibiæ of their legs form leaf-like expansions. Hence these insects rightly bear the name of **Walking Leaves** or **Leaf Insects** (*Phyllium*).

Others, again, the **Stick Insects**



STICK INSECTS. (One-half natural size.)
R., Species mimicking bark (*Cladoxesus phyllians*), from Brazil; D., species mimicking thorns (*Anophelepis despecta*), from Assam.

Digitized by Google

(*Bacillus*, *Bacteria*, etc.), bear a most striking resemblance to dry twigs: the body and legs are very long and thin, the wings are reduced to short rudiments, and the colour, which is made up of gray, brown, and black tints, is exactly like that of dry twigs. Added to this, the legs are placed in most asymmetrical positions, and in places have irregular lobe-like expansions, giving the whole insect the appearance of a dry twig with pieces of the bark stripped loose. The spectres are natives of Southern latitudes.

Group 3: Cursorial Orthoptera (Cursoria).

Family 6: Cockroaches (Blattidæ).

The blackish-brown, well-known, and much-detested insect, the **Cockroach** (*Periplaneta orientalis*), is met with in the same situations as the cricket. It has a variety of names, varying with different localities; on the Continent it is usual to call it by the name of the least popular of neighbouring nations, "Russian," "Frenchman," "Prussian," "Suabian," etc. During the daytime it hides in holes and crevices, but in the night it emerges from its hiding-places, and gnaws and scrapes at anything that is eatable. The males, with their long wings, are not at all unlike a beetle (hence popularly called "blackbeetles"). The females have only rudiments of wings, and are therefore incapable of flight.

The cockroach seems to have immigrated from the East, and to be by degrees supplanting the smaller dirty-yellow **German Cockroach** (*Blatta germanica*). (Compare with rat.) Both species do not deposit their eggs singly, but packed together in cases; and their hind-legs are not adapted for jumping, but are ordinary walking legs, as is also the case in—

Family 7: The Earwigs (Forficulidæ).

The **Common Earwig** (*Forficula auricularia*) is met with in gardens wherever it can find a suitable hiding-place. It is a perfectly harmless insect which lives on all kinds of vegetable substances, being specially fond of sweet fruits, but which never, as calumnious report has it, creeps into people's ears, and there does all kinds of mischief (name). The pincer-like appendages of the abdomen may be used occasionally for the purpose of inspiring fear in its enemy, after the manner of some savage warrior in terrible war-paint; but as a rule these organs subserve a quite different purpose. The wing-cases are very short, and cover large membranous hind-wings, which are folded both longitudinally and trans-

Digitized by Google

versely, but which (contrary to what obtains in other insects) cannot be unfolded by the help of the thoracic muscles alone. This is effected by the abdominal nippers, which by means of the elongated and flexible abdomen can be raised till they reach below the wing-covers.

ORDER VIII.: FALSE NET-WINGS (PSEUDO-NEUROPTERA).

MOUTH parts masticatory; prothorax free; fore and hind wings similar, transparent, with reticulate neurations, generally incapable of being folded up. Metamorphosis incomplete.

The Blue Dragon Fly (*Æschna cyanea*).

(Length about 2½ inches.)

The accompanying illustration will enable us easily to pick out this species from the large number of the Libellulidæ. It only remains to notice—

A. The Colour.

The forehead is marked by a black T-shaped spot; the great compound eyes meet in the middle, and are of a brilliant blue or green colour. The thorax is brown above, with two yellowish-green spots. The slender abdomen is brownish-black, marked with spots—in the male mostly of blue colour (name), but green in the female. The wings are of a glassy transparency, shot with yellow at their bases. Thus, the dragon fly looks a very handsome creature, especially as seen disporting itself over water and meadows. But its brief life is by no means given up to play, but rather to continuous slaughter, for this insect is—

B. A Pirate, pursuing its Prey in the Air.

This vocation explains the rapidity and deftness which mark all its movements. (Compare with raptorial birds, wasps, and other predatory animals of the air.)

1. The slender *body* cleaves the air with ease, the long and flexible *abdomen* serving as an excellent rudder during flight.

2. The insect is carried with ease on its four large transparent wings, which are traversed by many reticulated veins. The strong muscles which move the wings are all lodged in a

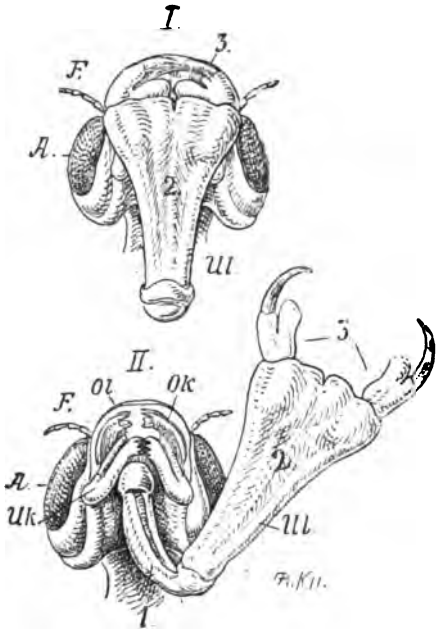
3. Very capacious *thorax* (see also Section 7).

4. The *head*, being united to the thorax by merely a thin stalk, is very movable, whilst

5. The eyes have the form of large hemispheres. These features enable the insect to survey a wide area in search of prey.

Digitized by Google

6. Small insects, May flies, etc., are no sooner spied than they are seized. Here, again, the great mobility of the head is brought into play. The actual organ of prehension is the peculiarly-constructed labium, which, in conjunction with the labrum, almost completely covers the remaining mouth parts. It consists of three portions, of which the two large lateral ones form the blades of a pair of nippers. While consuming its meal, the dragon-fly sits on a reed stalk or similar object, using its sharply-toothed mandibles and maxillæ for tearing the prey, which is held fast by



HEAD OF LARVA OF BLUE DRAGON FLY (VIEWED FROM BELOW). (Much magnified.)

I., With mask folded up; II., with the same unfolded. A., Eyes; F., antennæ; Ol., labrum; Ok., mandibles; Uk., maxillæ; Ul., labium, having the form of a mask; 1 and 2, its two elongated portions; 3, the pincer-shaped portion.

7. The *fore-legs*. These limbs, owing to the *prothorax* not coalescing with the other thoracic somites, are moved with much greater freedom than they would be otherwise (see p. 340). Apart from this, the legs are only used for clinging on to objects; they remain, therefore, very weak and light, which circumstance, again, influences the flight capacities of the insect. (Compare with swallow, butterfly, and other good fliers.)

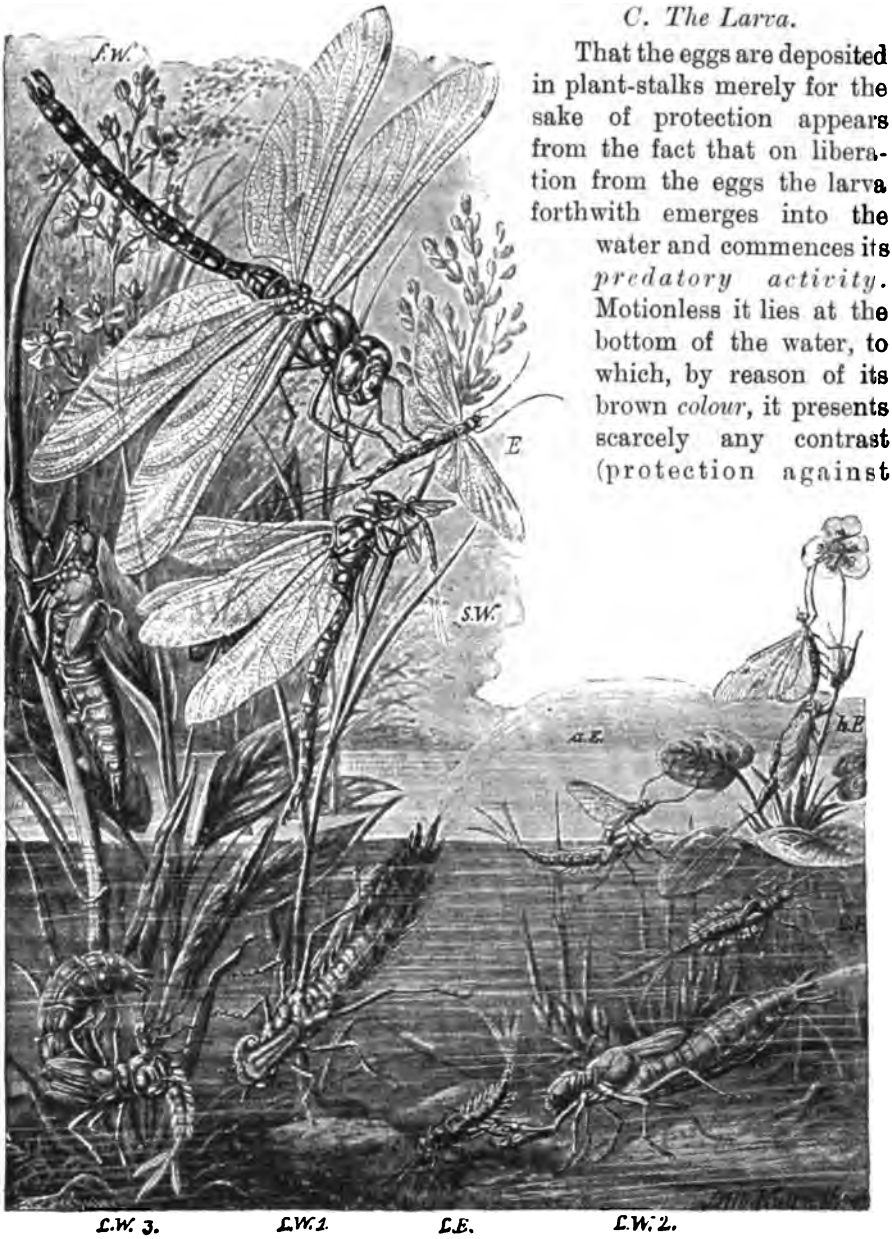
8. The dragon fly frequents the vicinity of water for two reasons: first, because it there finds a teeming multitude of gnats and other vermin, and, secondly, because

9. The female deposits its *eggs* upon water-plants. For this purpose, by means of an *ovipositor* (see ichneumon flies) upon the penultimate and antepenultimate somites, the insect pierces the stalk of the plant below the surface of the water, and in each puncture deposits an egg. (Other Libellulidæ simply drop their eggs into the water.) At the end of the abdomen there are two further processes forming a small pair of pincers, with which the male may be frequently observed clasping the female.

Digitized by Google

C. The Larva.

That the eggs are deposited in plant-stalks merely for the sake of protection appears from the fact that on liberation from the eggs the larva forthwith emerges into the water and commences its *predatory activity*. Motionless it lies at the bottom of the water, to which, by reason of its brown *colour*, it presents scarcely any contrast (protection against



BLUE DRAGON FLY AND MAY FLY.

f.W., Dragon fly on the wing in pursuit of a May fly (E.); s.W., dragon fly sitting eating a May fly; L.W.1., larva of dragon fly, with "mask" folded up; L.W.2., the same with mask extended, in the act of catching the larva of a May fly (L.E.); L.W.3., larva consuming a May fly larva (L.W.1. and L.W.2. squirting out a jet of water); L.h., larval skin of dragon fly, from which the perfect insect has escaped by the rent on the back; a.E., May fly escaping from the larval skin; h.E., one undergoing a second moult.

Digitized by Google

enemies and a cloak from its prey). When its large, powerful eyes have spied out a victim in the shape of an aquatic insect, a larva or the like, the creature slowly creeps towards it (*legs* very long). When still at about a third of an inch away from the unsuspecting victim, it suddenly seizes it and conveys it to the powerful biting organs (*mandibles* and *maxillæ*). The capture is effected by means of a most peculiar apparatus formed by the under lip, or *labium*, and composed, somewhat like the human arm, of three distinct portions. The two first elongated portions (upper and lower arm) are folded on each other during repose, so that the mouth from below looks as if covered by a mask. (Hence a labium constructed in this fashion is described as a raptorial mask.) The real organ of prehension (of which the two first portions form the stalk) is formed by the third portion, which represents a pair of pincers or a two-fingered hand. When the larva has approached sufficiently close to its victim, it suddenly projects this apparatus and seizes the unsuspecting prey. (Compare with the protrusible tongue of the chameleon and the flap-like tongue of frogs. See Fig., p. 400.)

If we watch one of these larvæ kept in confinement, we notice that it but rarely comes to the surface of the water, though breathing like all other insects by tracheal tubes. The exchange of gases in this case is effected by very fine gill-like lamellæ, in which the finest ultimate branches of the tracheæ terminate (*tracheal gills*). These lamellæ in the larva of the present species (as well as in those of many others) are found in the terminal portion of the intestine, which consequently has to be constantly supplied with a stream of fresh oxygenated water (intestinal respiration). If a larva confined in a vessel of water is lightly chased, it tries to escape by swimming forwards, which it accomplishes by violently ejecting water from the end of the intestine (compare with cuttle-fish). If we at the same moment can manage to depress the front end of the larva below the surface, we can see this water being squirted up to a fair height above the surface in the form of a jet (see illustration). This peculiar mode of progression is, however, only employed by the creature when fleeing from an *enemy*.

The *metamorphosis* of the larva to the perfect insect takes place gradually, as in the grasshopper (see p. 394); for although larva and perfect dragon-fly inhabit different media, they nevertheless lead essentially the same (predatory) mode of life. After living for some years in the water, the larva finally creeps up the stem of a water-plant, tears asunder its skin, and soars aloft as a perfect dragon fly.

Digitized by Google

Other Pseudo-Neuroptera.

Family 1: Dragon Flies (Libellulidæ).

In addition to the species above considered, we have a large number of other species which, leaving out separate details, essentially resemble each other in structure and mode of life, and whose larvæ lead an aquatic existence. Closely related to these is—

Family 2: The May Flies (Ephemeridæ). (See illustration, p. 401.)

All the species comprised in this family are very delicate in structure, and easily recognisable by the two or three long bristles on the abdomen. They make their appearance in innumerable swarms on warm evenings in the summer months (May to August). During their brief existence they take no food, but nevertheless cast their skins once after escaping from the larvæ. The empty skins remain sticking to water-plants and other objects. The larvæ also are aquatic. They breathe by leaf-like tracheal gills (see above) found on the sides of the abdomen, and kept in constant vibrating motion for the purpose of renewing the water of respiration (see fishes and crustaceans).

Family 3: White Ants (Termitidæ).

These insects inhabit warm countries, and live, like ants, in well-ordered societies. For this reason, and on account of their colour, they have received the name *white ants*. As among true ants, their communities consist of winged females and males, which, however, soon lose their wings, and of wingless workers, to which, as in some foreign species of ants, "soldiers" are added. The dwellings of the termites also vary much in the different species. In Africa, one species builds hills shaped like a sugar-loaf, from 14 to 17 feet high, and so hard as to resist even the tropical downpours of rain. These insects feed on anything that is eatable. They frequently invade human dwellings, destroying everything which cannot resist their sharp-biting, pincer-like jaws. As they work only in the dark, they generally consume the interior substance of objects—preferably the beams of houses—which then collapse on the slightest shock.

ORDER IX.: NO-WINGS (APTERYGOTA).

Mouth parts masticatory; wings absent; development without metamorphosis.

Among these, the lowest order of insects, we must place an inmate of our houses, the **Silver Fish** or **Sugar Mite** (*Lepisma saccharina*), an

Digitized by Google

elongated, active animal with three long bristles at the end of its abdomen. From its covering of silvery scales and a preference for sugar it has obtained its names; but it also feeds on wool, paper, and similar substances.

On the surface of standing water we often find thousands of minute black creatures which execute powerful jumps by means of a fork-shaped appendage on the penultimate abdominal somites, for which reason they are called **Water Springtails** (*Podura aquatica*).

One of their nearest relatives, the **Glacier Flea** (*Desoria glacialis*), inhabits the icy waters of Alpine glaciers. It is only during the summer, when the sun throws its burning rays upon the glaciers, melting ice and snow, that this peculiar insect is astir in the daytime, becoming on each succeeding night once more rigid with the cold.

CLASS II.: MILLIPEDES AND CENTIPEDES (MYRIAPODA).

Wingless articulated animals, breathing by tracheæ; body consisting of two divisions, the head and trunk; head provided with a pair of antennæ and two or three pairs of jaws; the body usually elongated, nearly every segment carrying one or two pairs of legs.

Millipedes are not infrequently discovered in *dark, moist places*, especially under stones and moss. They are all of *nocturnal* habits, and therefore of obscure *colour*. The *body*, being *long* and *wormlike*, requires, like a lepidopterous caterpillar (see p. 319), a large number of legs for its support (though there never are so many as a thousand, as the name implies). All the somites of the *body* being equally equipped with legs, and wings being never developed, none of the somites coalesce to form a distinct thorax, as is the case in (typical) insects (see p. 311). On the other hand, there is always a distinct *cephalic division*, or *head*, which supports the masticatory mouth parts, and carries the antennæ and numerous ocelli, or simple eyes (see p. 317). All the species multiply by means of eggs. Of the millipedes which come under our notice, two groups may be easily distinguished:

ORDER I.: CENTIPEDES (CHILOPODA).

These are rapid, furtively-moving creatures, with broad, ribbon-shaped body and a resemblance to wood lice (which see). The pliancy of their body and length of the legs, of which each segment carries a pair, endow them with that rapidity and nimbleness of movement required by their predatory mode of existence. The size and strength of their mouth parts are similarly adapted to this mode of life. By means of poisonous bites these nimble creatures can overpower animals much their superiors

Digitized by Google

in size (insects, worms, snails). The foremost pair of legs are modified into poison fangs, which are perforated by a canal. The **Scolopendras** (*Scolopendridæ*) of warm countries can inflict bites which may even prove dangerous to man.

ORDER II.: MILLIPEDES (DIPLOPODA).

THESE are harmless creatures, living for the most part on decaying vegetable matters, hence poison fangs are absent, and the organs of mastication are feeble. The body is usually cylindrical, and each somite carries two pairs (the first somites have only one pair) of short legs, on which the animals creep along slowly. On the approach of danger they behave like many other slow and defenceless creatures (examples): viz., they eject from apertures on their back drops of a fetid fluid, roll themselves up into a flat spiral or ball, and simulate death, as may be observed in the **Common Millipede** (*Iulus*) and the **Pill Millipede** (*Glomeris*).

CLASS III.: SPIDER-LIKE ANIMALS (ARACHNOIDEA).

AIR-BREATHING, articulate animals; wingless; the head and thorax usually coalescent into a single structure (cephalo-thorax), provided with two pairs of jaws and carrying four pairs of legs; legs never developed on abdomen.

ORDER I.: TRUE SPIDERS (ARANEINA).

The Garden Spider (*Epeira diadematа*).

(Length—male, $\frac{2}{5}$ inch; female, $\frac{3}{5}$ inch.)

A. Colour.

The colour of this species varies from brownish-yellow to black, and it is easily distinguished from the many others of our native spiders by the white spots on the dorsal surface of the abdomen, which are so arranged as to form a cross; the legs are lighter coloured, with darkish rings. Thus, the animal is of obscure appearance, which is in entire harmony with—

B. Its Favourite Habitats,

viz., dark bushes, trunks of trees, walls, garden-palings, etc., between which it stretches its snare or web (its colour thus protects it from insect-eating birds). It prefers the vicinity of water, where it finds in greatest abundance its—

Digitized by Google

C. Food.

This consists chiefly of flies and gnats. Being *wingless*, however, it is unable to pursue its prey into their own domain, the air, nor is it able to capture these light-winged creatures by running. Nevertheless, means must be found to get possession of its dipterous victims, and hence, like the fisherman, who cannot pursue his prey in the water, the spider puts up—

1. *A Net.*—Let us study more closely the manner in which the spider constructs this artistic contrivance, and by what structural arrangements it is adapted for its work:

(*a*) *Method of spinning the Web.*—The web is always stretched *vertically* between two supports—let us assume two tree-trunks. A *horizontal thread* is first stretched between the two supports, strong enough, and fixed sufficiently firmly, to carry the animal. This thread is first glued to one of the trunks, and carried by the animal over intervening branches (if there are such), as over a bridge, to the opposite trunk, where it is pulled tight and glued fast in the same manner. If, however, the two trees are separated by some intervening obstacle, *e.g.*, water or a ravine, and no connecting-bridge of branches is available, the spider, after gluing the thread to one of the trunks as described before, allows it to flutter freely, and to be carried by a current of air over to the opposite trunk, where it adheres easily to the rough bark.

Next a new thread is spun, and glued to suitable spots on the two trunks. In this manner an irregular polygon is produced, which forms the *frame* of the snare. Across this frame a diagonal thread is next spun, and from the point of its bisection threads radiate in all directions, like the *spokes* from the hub of a wheel. At the same time as the spokes a small disc of threads disposed in circles is spun gradually around the centre. By pulling at one of these threads the spider observes where an additional spoke may still be required. Finally, after all the spokes have been further connected by a wide spiral thread, the creature commences to draw another in a narrow spiral around the centre of the web; this is the real *snare thread*, and is studded with permanently viscid globules (see Section 2). The wheel-shaped snare is now complete, and, as a finishing touch, the spider destroys the first unadhesive spiral, which merely served as a bridge or ladder between the spokes.

The material for this ingenious structure is furnished by—

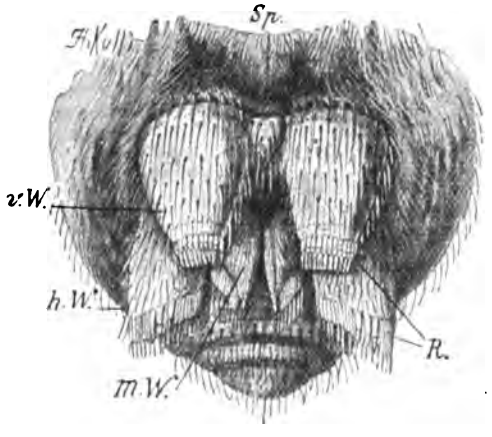
(*b*) Numerous large *spinning glands*, which lie in

(*c*) The *abdomen*, and account for its strikingly large size.

(*d*) The fluid matter from which the web is formed leaves the body by six very small wart-like prominences at the end of the abdomen, the

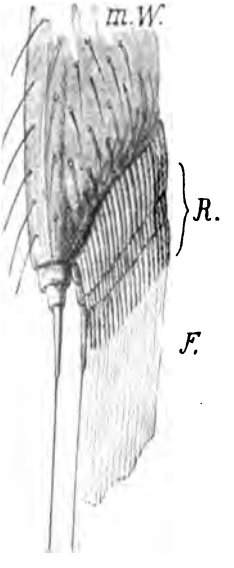
Digitized by Google

spinning mamillæ or *spinners*, through hundreds of extremely fine tubes, the *spinnerets*. Out of each of these tubes flows a drop of this silk matter, which by the movement of the spider is drawn out into a fine thread. The threads of the spinnerets unite, and, soon hardening, form a strong and firm silk line. Yet when all the glands are active, and silk flows from all the tubes, the thread which is formed is, in comparison with a human hair, as a strand of spun-yarn in comparison with a rope. Being composed of a large number of fibres, the spider's thread not only hardens very rapidly in the air, but also acquires a wonderful



UNDER SIDE OF ABDOMEN OF A GARDEN SPIDER WITH SPINNERS. (Strongly magnified.)

v.W., m.W., h.W., Anterior, middle and posterior spinners bearing on their surface numerous spinnerets. (Between the two anterior papillæ is a small conical body, the spindle, Sp., whose function is unknown.)



ONE OF THE MEDIAN SPINNING ORGANS (MAMILLÆ) IN ACTION. (More strongly magnified.)

m.W., The mamilla; R., two stout and numerous fine spinnerets; F., fibres of silk emitted from spinnerets.

firmness and uniformity of structure. (Explain this more fully. Which is stronger, an iron *rod* or a wire *rope* of the same thickness?

(*c*) Very dexterously the spider runs about over its web, only the tips of its legs touching the threads, and, which seems very remarkable, the creature never becomes enmeshed in the web like the flies and gnats, nor does it tear a single one of the delicate fibres. This is due to the fact that the animal walks exclusively on the *pectinated claws* of its feet, which, being very smooth, can be hooked into and lifted out from the

Digitized by Google

threads with equal ease. They are also used for fixing, smoothing out, and tearing off the threads.

In front of and between these pectinated claws is found a smaller, much-curved *ambulatory claw*, which probably protects the former from wear when the spider is running on hard surfaces. This claw, being provided with teeth at its base, is evidently also employed in spinning. The same applies to the toothed bristles placed immediately in front of it.

(*f*) The *four pairs of long legs* arise, as in insects, from the thorax, which, however, is fused with the head in a single portion, the *cephalo-thorax*. This division of the body encloses the muscles which move the mouth parts (see Section 3) and legs, and accordingly, unlike the softer *abdomen* (see Section C), is surrounded by a strong chitinous envelope (see p. 311). The two divisions of the body are united merely by a thin stalk.

LAST TARSAL JOINT OF GARDEN SPIDER. (Much enlarged.)

F., The pectinate tarsal claws; G., ambulatory claw; g.B., toothed bristle.

2. *Organs of Sense.*—When the snare is complete, the spider takes up a position in the middle of it or hides in some convenient recess, maintaining communication with the web, however, by means of a "signal line," which it draws after it. When a victim has got into the net and become adherent to the viscid drops of the spiral thread, the spider is forthwith made aware of it by the agitation of the "signal line," which is always kept taut, and at once pounces forth upon its victim. On the other hand, if the web is merely shaken by the wind, the spider does not stir from its hiding-place, which shows a wonderfully acute and discriminating *sense of touch*. The *sight* of the spider is, however, very feeble, and that in spite of its eight *eyes* at the anterior margin of the cephalo-thorax. (Indicate their position.) The spider is also said to be possessed of the senses of *hearing* and *smell*.

3. *Masticatory Organs.*—The spider kills its victim almost instantaneously by a poisonous bite of the finely-pointed, claw-like terminal joints of its *mandibles* or *chelicerœ*. These claws are traversed by a canal through which the poison, generated in a special poison gland, is conducted into the wound of the victim. During repose these claws are

Digitized by Google

folded down, like the blade of a pocket-knife, against the main muscular portion of the mandibles. Next, the prey having been fastened down by a few additional threads, the *maxillæ*, or *pedipalpi*, come into operation, each of which is furnished with a long, leg-like *palpus*. The food, after having been finely masticated, is then sucked in by the mouth.

4. *Peculiarities.*—Garden spiders are restricted in their diet to what happens "to fly into their mouths." Hence each individual must spin its own snare, and there can be no question of a "social state" in the case of these creatures. This *unsociability* extends even to the sexes, male and female being as a rule bitter enemies. Indeed, the male has usually to exercise great care to escape being devoured by the "stronger sex," the much larger female. The ability, also, of spiders to go without food for a considerable period is intimately connected with the manner in which they obtain their living. (Proofs.)

D. Respiration.

Leading a terrestrial life, the spider, like insects, breathes by tracheæ (see p. 315), to which are added two larger respiratory chambers—the so-called *lungs*. The entrances to the latter consist of two clefts, distinctly visible on the under surface of the anterior portion of the abdomen. The lungs have the form of sacs; from a portion of the wall of these, numerous plates, arranged like the leaves of a book (hence also called pulmonary lamellæ or pulmonary fans), project into the cavity of the chamber. In these lamellæ, which are of very fine structure and constantly fanned by the air, the exchange of the respiratory gases is effected (see Part I., p. 6). Respiration in spiders being thus partially localized (viz., in the pulmonary lamellæ), it follows that the blood must be conducted to these organs, whence the *vascular system* is more completely developed than in insects (see p. 315).

E. Reproduction.

Late in autumn the garden spider lays a number of yellowish eggs, which, as a protection against damp and enemies, it surrounds with a firm web. This little bag of eggs is then suspended in some concealed nook. With the reawakening of insect life in spring, the young spiders, too, escape from the eggs, and from the very first in all respects resemble their parents, thus not undergoing a metamorphosis like insects.

Other True Spiders.

Many different kinds of spiders are met with about the house, in the yard, in woods, and in the fields. All of them resemble the garden spider in structure, and are of predaceous habits, pursuing their prey

Digitized by Google

either by chasing it, or suddenly pouncing down on it from an ambush, or capturing it in snares of the most varied construction. The spider's webs which we see in the corners of rooms, stables, lofts, etc., are the work of the **Common House Spider** (*Tegenaria domestica*). These webs, which also form the animal's dwelling, are always stretched horizontally, and are funnel-shaped or tubular.

One species, the **Water Spider** (*Argyroneta aquatica*), actually lives in the water, where it chiefly pursues water-slaters (Asellus, which see). The abdomen of this spider has a velvety covering of hairs, and, just as a layer of air remains adherent to a velvet rag dipped in water (see otter), so this spider always carries a large silvery air-bubble down with it below the water. There it spins a dwelling not unlike a small diving-bell, which it anchors by threads to water-plants, and fills with air collected in the aforesaid manner. Thus the animal lives in air in the midst of the water!

On sunny days in autumn large numbers of fine threads, the so-called *gossamer threads* (what other names do they go by?), may be seen floating about over fields and meadows. On some one or other of these threads, if examined, we shall find a small (young) spider. This aerial vehicle is of the creature's own construction, having been produced in the following manner: Having ascended some elevated spot, such as a clod of earth, the spider spins a few short threads, which are fastened to the ground. These it grasps in order to obtain a firm hold. Next it once more presses the silk glands against the supporting surface, and elevates its abdomen. In this way a thread is formed, which, soon being seized by the wind, is drawn out longer and longer, blown hither and thither, and thrown into tangles, so that finally a small raft is produced. At last the wind lifts both the raft and its maker up into the air, and the aerial journey begins. Perchance the little ship will be stranded—agreeably to the wish of its navigator—in some spot where the latter may enjoy its winter rest in security, in order in the following year to spread its species.

In comparison to the spiders of tropical countries, even our largest species are mere dwarfs. The most familiar of these giants is the **Bird Spider** (*Avicularia*) of South America, which is covered with hairy fur, and will even kill small birds.

Other Arachnids.

In addition to the true spiders, numerous oth animals of very different structures are classed with the Arachnida.

Digitized by Google

ORDER II.: HARVEST SPIDERS (PHALANGINA).

THE most familiar member of this order is the long-legged **Harvest Man** (*Phalangium parietinum*). During the day this creature sits idly on walls or under stones; but in the night it leaps about in pursuit of all kinds of small insects and spiders. It does not construct a net. The mandibles terminate in small nippers (see crayfish); the abdomen is indistinctly segmented, and united to the cephalo-thorax along its whole breadth.

ORDER III.: SCORPIONS (SCORPIONINA).

THESE animals bear a much closer resemblance to a crayfish (which see) than to a spider. Like the former, they possess an elongated body, walk on four pairs of legs, while the large, leg-like, pincer-bearing pedipalpi (chelæ) bear some likeness to the fifth thoracic pair of legs of the crayfish. The small mandibles (cheliceræ) also have the form of nippers. Having seized its prey (an insect or spider) by the help of these prehensile instruments, the scorpion holds it aloft in order to inflict its deadly poisonous sting. The stinging organ is situated at the end of the abdomen, which, in order that the sting may be brought over or even in front of the head, not only has to be very elongated (see above), but also very flexible and movable. (Compare with earwig.) It owes the last of these qualities to the fact that it consists of distinctly separate rings, of which the seven anterior ones are broad, the six posterior ones extremely narrow and freely moveable. Scorpions are predaceous animals of nocturnal habits, and therefore dark colour. They do not sting man except in self-defence, but are much detested on account of their poisonous nature. The sting of the larger species inhabiting tropical countries may even cause death.

Even the **Field Scorpion** (*Buthus occitanus*) of Southern Europe, which attains to the length of just over 3 inches, can inflict dangerous stings.

On the other hand, the sting of the **House Scorpion** (*Scorpio Europæus*), also a native of Southern Europe, and about 1¼ inches long, has no more serious effect than that of a wasp.

ORDER IV.: BOOK-SCORPIONS (PSEUDO-SCORPIONINA).

THESE animals are very similar to the true scorpions. The most familiar member of the order is the **Common Book-Scorpion** (*Chelifer cancroides*). The rounded shape of the abdomen, which is only slightly movable, harmonizes with the absence of a poison sting. The body is much

Digitized by Google

flattened, thus enabling the animal to live among old papers and in mouldering books, where it pursues book-lice (*i.e.*, small Orthoptera) and mites.

ORDER V.: MITES (ACARINA).

The most familiar of these minute creatures are the beautiful scarlet-red **Scarlet Mites** (*Trombidium holosericeum*) and the **Water Mites** (*Hydrachnidæ*). The former we often meet with on green plants, and the latter, frequently in large numbers, in lakes, ponds, and pools. Both display distinctly the characteristic features of mites—viz., the thick-set, unsegmented body, in which neither head, thorax, nor abdomen is distinguishable. They live parasitically on the body-juices of other animals either during their youth only or throughout the whole of their existence. In fact, among the mites parasitism is general.

The **Beetle Mite** (*Gamasus coleoptratorum*) lives as a bloodsucker on the bodies of insects much employed on the ground. (Name such.)

The **Bird Mite** (*Dermanyssus avium*) infests birdcages and poultry-coops, and attacks the birds during the night.

The **Ticks** (*Ixodidæ*) frequent dry woods. The females when they have an opportunity bore into the skin of mammals, where they swell up to the size of a bean. Even man is liable to be attacked by these pests. By covering them with oil the creatures are forced to detach their sucking proboscis, which, if force be used, remains in the wound and causes inflammation.

The **Cheese Mite** (*Tyroglyphus siro*) and its kindred live, often to the number of millions, upon hard cheese and on dried fruits (plums), where they form a white crust.

To this order also belongs the **Itch Mite** (*Sarcoptes scabiei*), a small microscopic parasite which bores its way under the skin of man, and there forms long tunnels of hairy fineness. It there multiplies with incredible rapidity, causing the disgusting disease known as the "itch."

The "scab" or "mange" of dogs and other domestic animals is also caused by mites.

CLASS IV.: CRABS AND THEIR RELATIVES (CRUSTACEA).

Articulate animals, breathing by gills (or merely by the skin); almost exclusively aquatic; usually possessing two pairs of antennæ, and a pair of appendages on every segment.

Digitized by Google

GROUP I.: THORACOSTRACA.

ORDER I.: TEN-LEGGED CRUSTACEA (DECAPODA).

The Crayfish (*Astacus fluviatilis*).

(Length up to 8 inches.)

A. Its Occurrence and Habitat.

THE fresh-water crayfish is plentiful enough in some English rivers, *e.g.*, the Thames. It is to be found also in considerable numbers in the artificial channel known as the New River, which supplies part of London with water.

The streams and rivers of Germany are now as poor in crayfish as they once were rich in these animals; indeed, in many waters these creatures, so highly esteemed on account of their excellent flesh, have been totally exterminated. This is chiefly owing to a disease, the *crayfish pest*, which in 1876 made its appearance in France, and spread thence further and further east. Man, however, is not without his share in the blame of the depopulation of the waters. The capture of the crayfish was in many cases carried on in a most reckless fashion, neither young nor females with eggs (see Section C) being spared, with the result that all the progeny was destroyed. Manufactories also emptied their poison-laden waters into streams and rivers and killed these sensitive animals, to whom pure water is a primary necessity. (We shall see later what other conditions must be satisfied by the waters inhabited by the crayfish.)

During the day the crayfish rests in some safe hiding-place, under stones, among the roots of plants growing on the banks, or in holes, which it digs out for itself with its great claws (which see). Hence, in the second place, the crayfish prefers streams where it can find recesses of this description ready formed for it, or where the banks are of such formation that it can easily dig them out for itself. Not until darkness sets in does the animal leave its haunt in search of food.

B. Structure of Crayfish.

i. Segmentation of the Body.

A mere superficial glance shows that the body of the crayfish consists of two distinctly separate portions. The anterior of these divisions corresponds to the head and thorax of the body of an insect (see p. 311), both of which here (as in spiders, see p. 408) are intimately united to form the *cephalo-thorax*. The original division of the two portions is, however, still indicated by a curved transverse furrow (cervical groove),

Digitized by Google

which extends across the dorsal carapace. (The crustaceans in which the cephalo-thorax is wholly or partially covered by such a carapace form the large division of the so-called Armoured Crustaceans, or Thoracostraca. The carapace goes by the familiar, or kitchen, name of "head.") From the cephalo-thorax the somewhat narrower abdomen ("tail") is distinctly separated. Both divisions of the body carry a large number of *limbs*, varying considerably in structure, according to the different functions assigned to them.

ii. Exoskeleton, or "Shell."

All the parts of the body are encased in a solid armour, which serves as an important protection to the animal against enemies and injuries. Like that of all arthropods, it consists of chitin (see p. 308), but acquires great firmness by the deposition in it of *calcareous salts*. (Hence the name "crustacean." Remove the salts by soaking the shell in dilute hydrochloric acid; of what does the soft flexible portion which remains consist?) The chalk is derived (as in molluscs, see vineyard snail) from the food, and separated by the blood simultaneously with the chitin over the whole surface of the body. Hence a third condition to be satisfied by the water to render it suitable for the habitat of the crayfish is that it contain calcareous salts. Like all arthropods, the growing crayfish is obliged to cast its shell periodically in order to form a more capacious one (see p. 310). The new envelope, however, is at first very soft, and the animal, being, therefore, quite defenceless during this condition, carefully endeavours to hide itself until its armour has regained its hardness, which takes place pretty rapidly (in from eight to ten days); for even before the *moult* a store of calcareous material has been accumulated in the body in the form of two lenticular masses known as "crabs' eyes," to which formerly peculiar healing properties were attributed. They are found embedded in the lateral walls of the stomach, and during the moult are dissolved and carried into the blood.

iii. Colour.

The colour of the animal also has its seat in the shell of the animal, and adapts itself in a high degree to the bottom of the water it inhabits. Thus, crayfish which live on the light-coloured bottom of clear lakes are of a light greenish colour (thus, in a lake in Poland, the waters of which are of crystalline clearness, "light green, nearly white" crayfish are found); on the other hand, those living in the dull waters and on the dark bottoms of rivers vary from brown to almost black. (Explain these phenomena by comparison with the ringed snake and other animals.)

Digitized by Google

The colour is produced by various pigments (green, brown, blue, and red), and the colour of the animal depends upon which of these tints predominates. In the process of cooking all the pigments are changed to red, the characteristic colour of all boiled crustaceans ("red as a boiled lobster").

iv. Organs of Sense.

1. Even while resting in its hiding-place (see Section 2) the crayfish usually allows its *antennæ* to protrude. They are moved to and fro, apparently in play, but really for the purpose of reconnoitring the ground, to see whether there may be a prey to be captured by a rapid surprise attack or an enemy lurking in ambush (see Section C, ii.). Of these sensitive tactile organs, the crayfish, like all crustaceans, possesses two pairs. Those of the first, or inner, pair each carry two short flagellate appendages, the "antennules," and contain the organs of smell; while those of the second, or outer, pair are each provided with one similar, but much longer, appendage, the "antennæ." Upon the first of the three basal joints of the antennules (protopodite) is found a small vesicle, to which naturalists also assign a sensory function; but it is not decided whether it serves as an organ of hearing, or merely for the purpose of maintaining the animal's balance.

2. At the place where the carapace (see Section B, i.) is prolonged forwards into what is known as the beak or "rostrum" are placed the large *eyes*, which are constructed on exactly the same plan as the compound eyes of insects (see p. 316). Being placed on stalks movable in all directions, they enable the animal to survey a wide circuit (food, enemies), and even to look backwards, which is of great advantage to the creature during its retrograde movements (see Section vi., 2). During rest the eyes are laid in pits by the side of the rostrum, which at the same time protects them from injuries in front.

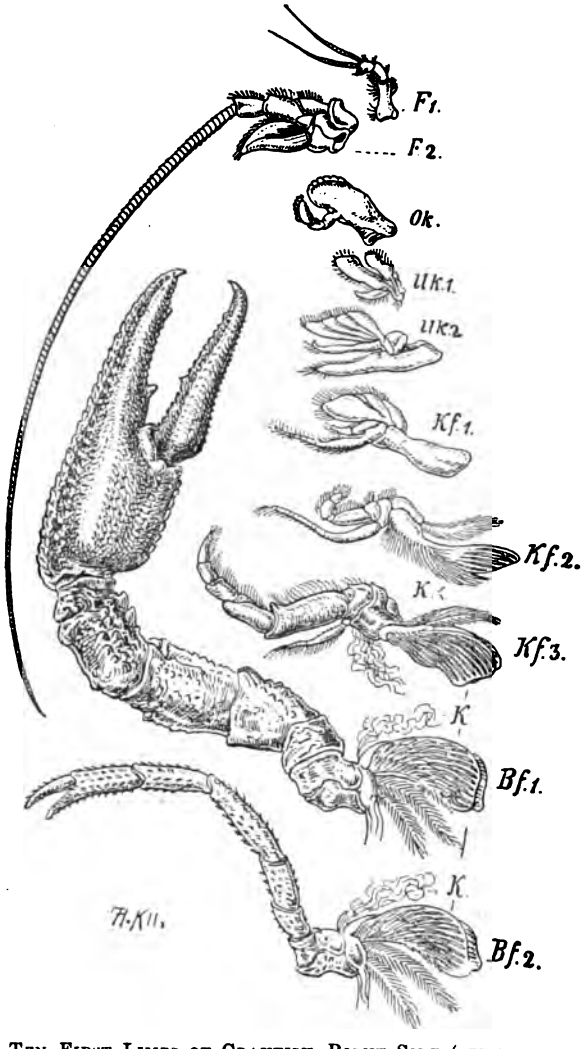
v. Organs of Mastication and Digestion.

The crayfish is an *omnivorous* creature, feeding by preference on worms, snails, fish, frogs—in short, all kinds of animal substances. In case of necessity, or for the sake of variety, it also consumes the roots and young shoots of water-plants, and when very hard pressed even carrion. Being of very voracious habits, the crayfish avoids rapidly-running waters, since these are usually poor in food.

1. The crayfish is not able, like a fish, to swallow its prey whole, for its mouth, which is placed on the ventral surface of the body, is incapable of dilatation, and represents merely an opening in the rigid armour.

Digitized by Google

Besides, the animal is compelled to hold fast its prey, which otherwise would soon be washed away, especially in running water.



TEN FIRST LIMBS OF CRAYFISH, RIGHT SIDE (SEEN FROM BELOW). (Slightly enlarged.)

F.1. and F.2., Antennules and antennæ; Ok., mandibles; Uk.1. and Uk.2., first and second maxillæ; Kf.1., Kf.2., and Kf.3., first, second, and third maxillipedes; Bf.1. and Bf.2., first and second ambulatory legs; K., branchiæ.

2. Accordingly, the crayfish must be provided with organs for holding and dividing its prey. Such organs are the large *pincers or claws of the first pair of thoracic legs* (see Section vi.), which, on account of their great strength, serve also as prehensile and defensive organs. They are formed on the general plan of shears, viz., by the last joint of the limb being movably opposed against a prolongation of the penultimate joint. These pincers cannot, however, be brought in contact with the mouth (show this by trial), which is effected by

3. The much smaller *pincers of the two succeeding pairs of limbs*, by means of which the detached portions of food are conveyed to

4. The *mouth parts*. Of these there are six pairs. The foremost, called the *mandibles*, consists of a hard-toothed, masticatory portion, which is seen at a glance to be the principal instrument for dividing up the food. (Compare with mandibles of insects possessed of masticatory mouth

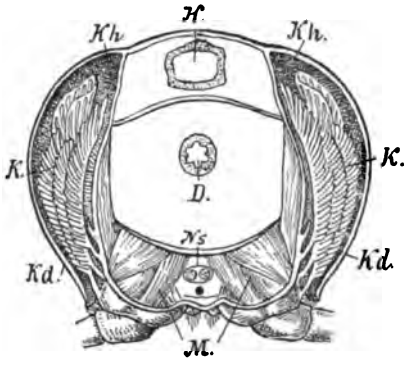
Digitized by Google

parts.) The two following pairs, or *maxillæ*, are without these hard, masticatory parts, as are also the three last pairs, which have more the character of limbs, and are therefore known as *foot-jaws* or *maxillipedes*. Their function consists not so much in dividing up the food as in passing on the morsels conveyed to them by the large pincers, and to prevent them from being washed away by the water. This also explains the large number of these mouth parts, and their increasing size as we pass from before backwards. In the last pair, which covers all the other mouth parts from below, the longest (basal) joint has a very sharp inner edge, which adapts it admirably for scraping off the scales of fish. (As to the importance of the foot-jaws as accessory respiratory organs, see Section vii.)

5. The complete division or trituration of the food, however, as in grain-eating birds (see Part II., p. 197) and several insects, takes place in the *stomach*, the walls of which are fortified by blunt-toothed, chitinous masticatory plates rubbed against each other by powerful muscles.

vi. Organs of Locomotion.

1. On its five long pairs of thoracic or ambulatory legs ("decapod crustaceans"), the crayfish strides along slowly as if on stilts (gressorial feet). It never walks backwards unless alarmed. In creeping along, the animal does not as a rule make use of the powerful pincers of the first pair of legs, though these are of help to it as climbing organs in surmounting obstacles. Their other uses have been already discussed. (Compare Section A and Section v., 2.)



TRANSVERSE SECTION THROUGH THORAX OF CRAYFISH (SOMEWHAT DIAGRAMMATIC). H., Heart; D., intestine; Ns., the two nerve cords cut across; K., branchiæ; Kd., branchial cover (branchiostegite); Kh., branchial chamber; M., muscles of legs.

2. On the approach of an enemy, however, the crayfish takes to flight as rapidly as possible. In escaping, it swims off in jerks by executing violent strokes with its *abdomen*. These strokes, being directed forwards, impel the crayfish backwards. (If we stand at the prow of a boat, and with the oar force the water away from the boat, the latter is driven backwards. What is the behaviour of the crayfish when taken out of the water? Why can it not capture a fish or frog *swimming*?) Thus the abdomen forms a very important organ of locomotion:

(*a*) For this reason, also, almost the whole of its interior is occupied

Digitized by Google

by muscles, as anyone knows who has eaten crayfish or lobsters. (Compare with the tail of fishes.)

(*b*) As great mobility is required for the execution of the strokes, we find that the abdominal somites are distinctly separated from each other. (Contrast this with the cephalo-thorax.)

(*c*) Laterally the somites are *widened out*, and are curved in such a manner that the whole abdomen forms a scoop which exerts considerable force in striking the water.

(*d*) The so-called *tail fin*, also effects a considerable enlargement of surface. It consists of five plates, of which the central one represents the last abdominal somite (since it carries the anal aperture), whilst the lateral plates are the much-expanded branches (exopodite and endopodite) of the appendages of the penultimate (sixth) abdominal somite, similar to those attached to the under surface of the other segments of the abdomen (see Section C, i.).

vii. Respiratory Organs.

The crayfish, as a typical aquatic animal, breathes, like the fish (see Part II., p. 272), by *gills* or *branchiæ*. These lie at the sides of the carapace in the so-called *branchial chamber*, and consist of very fine plumes and filaments attached to the second and third pairs of foot-jaws and to the first four pairs of walking legs. These delicate organs are protected by a cover formed by the sides of the cephalo-thorax, analogous to the gill-cover in fishes, and, just as in the latter, the branchiæ require to be bathed by a constant stream of water. If we watch the under surface of a crayfish which has been introduced into a glass vessel, we shall see that the plate-like second pair of maxillæ vibrate rapidly to and fro, and also that the flagelliform appendages of the two last foot-jaws are in constant motion. If a small quantity of a not easily soluble pigment (*e.g.*, carmine) be now added to the water, we observe that the grains of pigment are swept away from the vibrating mouth parts, showing that the respiratory current is directed from behind forwards, thus corresponding to the direction assumed in swimming.

Dirt particles, if allowed to be deposited upon branchiæ or to block up the outflow from the branchial chamber, would impede the function of these delicate organs. To prevent this, the free edge of the gill-cover, which lies close up against the body, is beset with fine hairs, and, like a strainer, holds off all solid constituents of the inflowing water from the branchial chamber. Hence, also, it is necessary that the water inhabited by the crayfish should be clear and the bottom not covered with loose mud, which would be constantly stirred up by the animal while striding through it. (Why can crayfish live for a considerable time out of the water? Compare with fishes, Part II., p. 274.)

Digitized by Google

viii. Circulation.

Thus, in the crayfish the organs of respiration are restricted to a few definite portions of the body, *i.e.*, the branchiæ. Accordingly, as in Vertebrata (see Part I., p. 7), *bloodvessels* must be developed by which the (colourless) blood, loaded with carbonic acid, is conveyed to the gills, and thence, after being purified, to the heart. (Contrast with insects.)

C. Reproduction of the Crayfish, and Enemies.

i. Reproduction.

Among crayfish offered for sale during winter and spring, we always notice a number having *eggs* adhering to their abdominal feet (said to be "in berry"). These are females. They carry the eggs about with them until the young are ready to escape. In this manner they protect them from numerous dangers, and also by constant movements of the abdominal legs provide them with a constant supply of fresh water. The latter is the more necessary, inasmuch as the females during this period retire into their holes and but seldom go in search of food. The *young crayfish* also for some time allow themselves to be carried about by the mother, adhering by their pincers to the setæ of its swimmerets. This *nurture of the brood* also explains why the crayfish produces a much smaller number of eggs than, *e.g.*, fishes (see p. 277); and it also furnishes it with a means of holding its own against its numerous enemies.

ii. Enemies.

Amongst these, in addition to man (see Section A), we must class the otter and water rat, the eel and the perch. Other means of protection have been already dealt with, viz.: its concealment in holes, its colour, the acuteness of its senses, its rapid movements when alarmed, its hard shell and powerful claws.

Other Decapod Crustaceans.

Crustaceans fill in the water the place of insects on the land. They inhabit the sea in immeasurable numbers and astonishing variety, and are to man the source of a productive industry.

Among the crustaceans of the coast of Europe, the **Lobster** (*Homarus vulgaris*), which, however, is not found in the Baltic, is undoubtedly the most important. This large creature, which may reach a length of 18 inches, hides under stones, in rock caverns, and among the tangle of marine plants, on the look-out for such prey as may happen to swim past, which it seizes by suddenly projecting its powerful toothed chelæ.

Digitized by Google

Hiding-places of this kind, however, are only to be found on a rocky bottom, and hence the lobster only frequents those parts of the sea where the bottom is of this nature, to the colour of which, moreover, that of the animal closely assimilates.

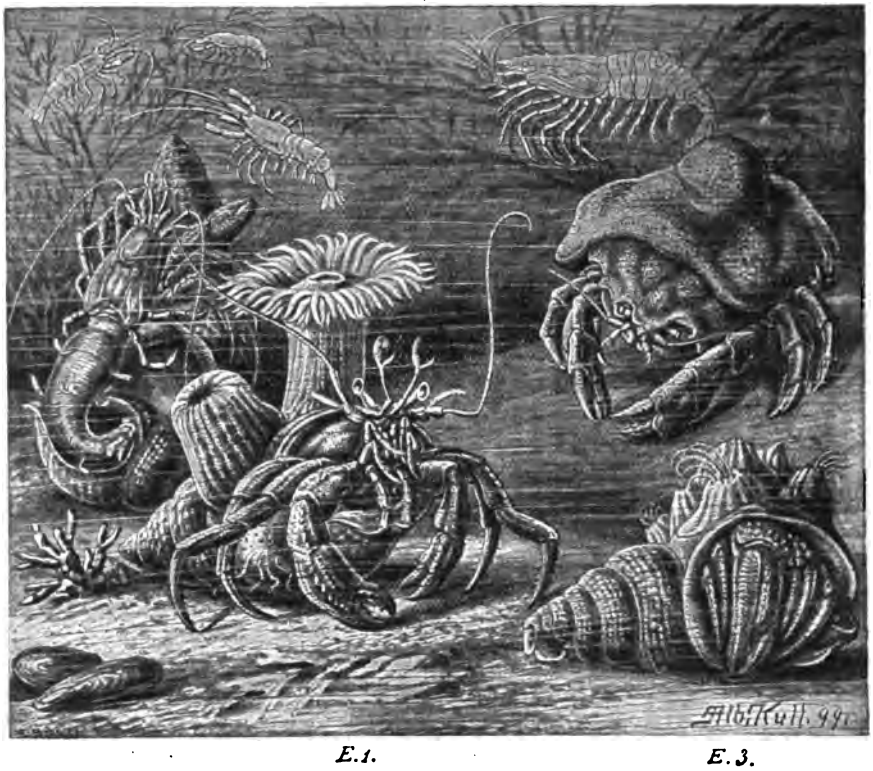
A very similar species, the **Spiny Lobster** (*Palinurus vulgaris*), is found from the Mediterranean to the south-west coast of England. This animal is unprovided with prehensile weapons (no pincers are developed on the legs). Its only protection against hostile attacks consists in its strong spine-covered shell.

The **Shrimps** are small marine crustaceans, which, after being boiled, are sent considerable distances inland. By their colour alone we can separate them into two distinct species, viz., the **Prawns** (*Palæmon serratus*), which are of a bright red colour after boiling, and a grayer kind, the **Common Shrimps** (*Crangon vulgaris*), whose colour even after boiling is little different from that which during life hid them from the view of their enemies on the sandy bottom. Their long abdomen, the large abdominal legs, which are used as oars ("swimmerets"), and the long tail fin, all point out these animals as excellent swimmers.

On the other hand, the adults of the **Hermit Crab** (*Paguridæ*) are totally incapable of swimming, for their swimming organ, the abdomen, is so soft that the animal is obliged to use a mollusc shell for its protection, and thus becomes a "hermit" (name). The animal crawls backwards into this alien dwelling, which it only abandons when the shell is too small for it, *i.e.*, when its body has grown too large for its house. The crab is then obliged to exchange it for another roomier one. The animals retain hold of their dwelling by means of their terminal abdominal appendages, which have been modified into clasping organs, and the two last thoracic legs. Only the hard-shelled portions of the body and the eyes on their long peduncles protrude from the shell. Protected by this strong castle, the animal goes in pursuit of prey, and on the approach of any danger withdraws as far as possible into its fortress, the entrance to which is barred by one of the two claws, which for this reason is much larger than the other. Some species of these peculiar crustaceans further protect themselves by contracting a kind of "friendly alliance" with certain sea-anemones (which see), particular species of the latter being regularly found on the shells occupied by the hermit crab; and it has been stated that when the latter enters a new dwelling it carefully with its claws removes the anemone from the old house and transplants it to the new one. Placed under the protection of the stinging "nettle threads" of the anemone, which are carefully avoided by all sensitive animals, the hermit crab is

Digitized by Google

not easily approached by its enemies. The anemone, in its turn, finds a most profitable situation upon the mollusc shell, for in the first place it picks up many a morsel which falls from the table of its host, and, secondly, from its place of settlement it participates in the constant



MARINE CRUSTACEA IN THE AQUARIUM.

E., Hermit crabs in the shells of whelks (about one-half natural size); E.1., shown in creeping attitude; two specimens of a sea-anemone (*Adamsia rondeletii*), Sr., have settled on the shell, one with tentacles expanded, the other with the same retracted; E.2., hermit crab leaving the mollusc shell, which has become too small, in order to migrate to a larger one; E.3., hermit crab withdrawn inside shell; on the shell of the whelk are shown a few "acorn shells" (*Balanus*, see p. 426), with their "cirri" partly extended; K., Woolly crab (*Dromia vulgaris*), holding over its back, by the claws of the two last legs, a living sponge (*Suberites*) (about one-half natural size); Sg., common shrimps (the largest about one-half natural size); G., a prawn (about three-fourths natural size).

migrations performed by its host in search of food, and is therefore itself able to obtain much richer spoil than if it remained fixed upon its rock and compelled to wait for what food chance conveyed to it. We have here, therefore, an instance of the "commensalism" of two entirely

Digitized by Google

distinct animals, from which each of the two "commensals" derives some advantage.

All the crustaceans hitherto discussed have a well-developed abdomen (tail), and are therefore described as **Long-tailed Decapods** (*Macrura*). In contrast with these we have a large number of crustaceans in which the abdomen is very short and turned forwards underneath the cephalothorax, which is usually disc-shaped.

These form the group of **Short-tailed Decapods**, or **Crabs** (*Brachyura*), the most familiar examples of which in our seas are the common **Shore Crab** (*Carcinus mænas*), about 1½ inches long, and the larger **Edible Crab** (*Cancer pagurus*), about 4½ inches long.

In these animals the abdomen is rudimentary, and for the most part they progress by walking. Their branchial chambers being tightly closed, many of them are shore-dwellers, being able to live for a considerable time without detriment out of the water.

Some slow-moving and exclusively aquatic species—like, *e.g.*, the **Spider Crab** (*Maia squinado*), common in the Mediterranean and on the west coasts of Europe, and reaching a length of about 7 inches—often resemble walking gardens, their backs being densely covered with a growth of seaweed, sponges, zoophytes, etc. These arrangements afford an excellent protection against enemies lurking in ambush, and also conceal the animals from the prey they are stalking. Several species, indeed, intentionally assume this "disguise," covering their backs with these foreign bodies, whilst some hold such objects constantly over themselves with the claws of the two last pairs of thoracic legs.

ORDER II.: MANTIS-SHRIMPS (STOMATOPODA).

Among the Thoracostraca must also be placed the peculiarly-shaped **Mantis Shrimp** (*Squilla mantis*) of the Mediterranean. In this species the carapace, however, does not cover the three last segments of the thorax, while the first two pairs of thoracic legs have been modified into accessory masticatory organs (maxillipedes). The second maxillipedes form powerful raptorial legs (see praying mantis), with which the animal seizes its prey; whilst the last three similarly-constructed, but smaller, maxillipedes are used for tearing the victim in pieces. (Hence name Stomatopoda, *i.e.*, "mouth-footed.")

GROUP II.: ARTHROSTRACA.

The crustaceans comprised in this large division are distinguished from the Thoracostraca by the majority of the thoracic segments not coalescing with each other and with the head, and by the absence of a carapace covering these parts.

Digitized by Google

ORDER III.: SAND AND SHORE HOPPERS (AMPHIPODA).

In streams and rivers are found small crustaceans, ranging from ⅓ to ⅔ of an inch in length, which from their appearance have been called **Fresh-water Shrimps** (*Gammarus*). They jump by means of the three last large legs of the thorax, which are directed upwards, and the three last abdominal legs, which are bifid. They swim by executing forcible strokes with their movable abdomen. Their progress through the water is assisted by the shape of their body, which is strongly curved and laterally compressed. The three anterior abdominal legs are in constant motion, even while the animal is at rest, being engaged in driving a current of water towards the branchial appendages of the thoracic legs. In the females, a number of plates under the thorax are inclined towards each other, so as to form a cavity for the reception of the eggs. The majority of the Amphipoda live in the sea or on the seashore.

ORDER IV.: SLATERS AND WOOD LICE (ISOPODA).

In these crustaceans the body is broad and flattened; the animals, accordingly, only progress slowly by creeping along the ground, or by rowing themselves lazily through the water. Their branchiæ are formed by the abdominal legs, which are specially modified for the purpose.

In the **Water Slater** (*Asellus aquaticus*), which is common everywhere, these organs may be seen in constant motion. As the terrestrial species (rock slaters and wood lice) also breathe by gills, they live in damp, moist situations. Many, like, *e.g.*, the familiar wood-louse (*Oniscus*), cannot even live for a night in the air of an ordinary living-room.

Another species frequently met with is the **Armadillo** (*Armadillidium vulgare*). (Compare with pill millipede, p. 405.) Among the Isopoda, the young brood is nurtured and protected in the same way as in the Amphipoda.

GROUP III.: LOWER CRUSTACEANS (ENTOMOSTRACA).

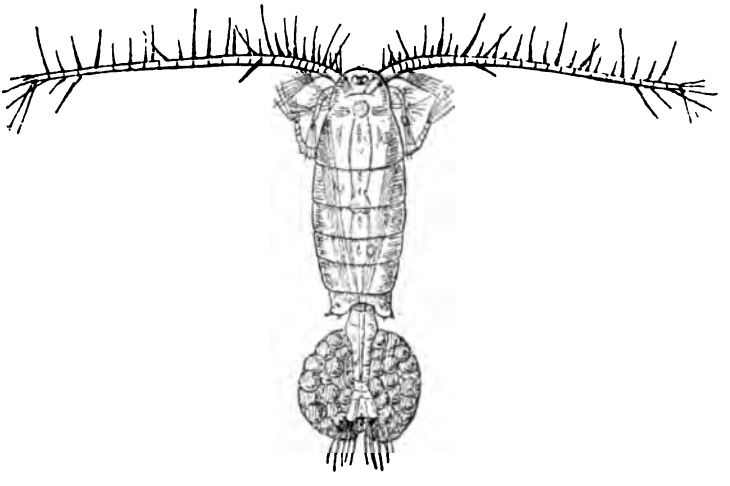
If a fine gauze net be drawn through the water of a pond or pool, and then washed into a bowl of water, we shall find that we have captured a quantity of minute creatures. These, in addition to insect larvæ, water mites, and infusoria, will be found to consist for the most part of crustaceans, which, however, bear little resemblance to the crayfish. The largest of them do not exceed a fraction of an inch, but many, by reason of the vast quantities in which they occur, are of great importance

Digitized by Google

in the economy of Nature, as forming the food of many larger animals. Among these small crustaceans three groups may be easily distinguished.

ORDER V.: OAR-LEGGED CRUSTACEA (COPEPODA).

THESE are narrow and somewhat elongated creatures, which skip swiftly through the water, and form, as we have already learnt, an important item in the food-supply of the herring (which see). Among them we are sure to find many (females) which carry about with them one or two masses of eggs until the larvæ are hatched. All are of so delicate a texture (aquatic animals; see fresh-water polyp) that they breathe by their skin, and therefore dispense with branchial organs;



A FRESH-WATER COPEPOD (*Diaptomus*). (Magnified about thirty times.)
Female with a mass of eggs attached to the first abdominal segment.

many, even, do not possess a heart. On the front of the head, between the long first pair of antennæ, is situated a single median eye. Like the members of the two other groups, they multiply with astonishing rapidity, so that standing waters are often in a short time populated by them in millions.

ORDER VI.: BIVALVED CRUSTACEA (OSTRACODA).

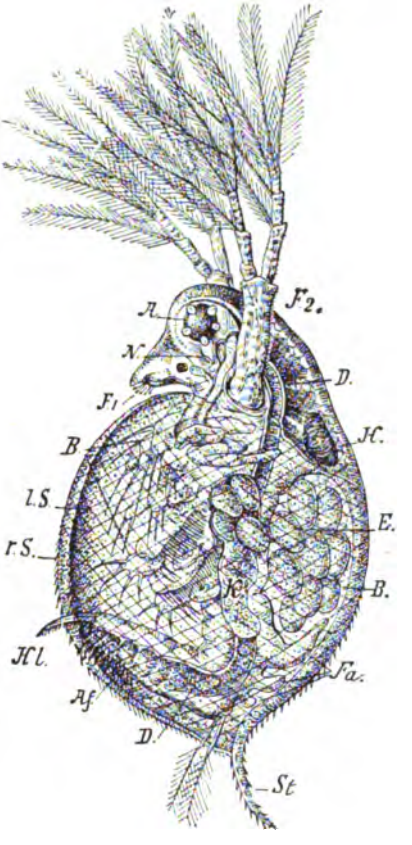
IN these minute Crustaceans the body is enclosed in a minute bivalve shell, giving them the appearance of tiny bivalve molluscs. When, however, the animals protrude their antennæ, which they use as oars, from between the two valves of the shell, we see at once that we are not dealing with molluscs, but with arthropod animals.

Digitized by Google

ORDER VII.: LEAF-LEGGED CRUSTACEA (PHYLLOPODA).

In this group, of which **Water Fleas** (*Daphnia*) may be taken as familiar examples, the body is enclosed within a saddle-shaped shell. They are, however, easily distinguished from the Ostracoda by the two large arm-like organs (second pair of antennæ) developed on their head, by the help of which they move in jerks through the water. Most of these delicate creatures are of glassy transparency, so that not only all their internal organs and the cavity in which the larvæ are developed, but also the beat of the heart and the circulation of the blood, may be observed from without. These creatures are placed in the order Phyllopoda on account of their foliaceous (gill-bearing) feet.

To the same order also belongs the interesting genus *Apus*. This animal measures about 1¼ inches in length, and carries a large dorsal carapace and a large number of pairs of feet, which are kept in constant vibratory motion. It is found only in spring in standing pieces of water which had previously completely dried up, for, strange to say, its eggs require to have lain dry for a time before they can be hatched.



A Water Flea (*Daphnia zschokkei*) lying on its Right Side. (Magnified about thirty times.)

l.S. and r.S., Left and right halves of the saddle-shaped shell, terminating in the spine (St.); of the right half of the shell only a small portion is visible; between the two halves some of the spines of the abdomen (Hl.) are seen protruding; F.1. and F.2., first and second pairs of antennæ; B., foliaceous feet; A., compound eye (with five lenses); N., portions of the nervous system (nerve ganglia); D., intestine, terminating in Af., the anus; H., heart; K., ovary, from which several freshly developed ova (E.) are entering the "brood pouch" (B.), which is closed behind by three folds (Fa.).

ORDER VIII.: BARNACLES (CIRRIPEDIA).

To objects floating on the sea we often find permanently fixed elegant-looking organisms, borne upon movable stalks, and, like mussels, enclosed within hard shells. From their external resemblance to molluscs, they were accord-

Digitized by Google

ingly formerly classed with the latter, there being a further popular superstition that they gave origin to ducks—whence in Germany the name for **Barnacles** (*Lepas*) is duck mussel (*Entenmuschel*). It is only a study of their development that has revealed these animals to be crustaceans. Their larvæ were, in fact, found to be free-swimming organisms, resembling in all respects the larvæ of other crustaceans. Only after several metamorphoses they become fixed to some solid object, and assume the shape and form of the barnacle. By means of delicate tendril-like appendages called cirri, which may be seen protruding from a cleft in the shell, these animals sweep a constant current of water laden with food into their interior.

To this order also belong the unstalked or sessile **Acorn Shells** (*Balanus*), which may be seen at low water, looking like small warts, fixed to rocks, shells of molluscs, etc. (see illustration, p. 421).

Digitized by Google

DIVISION OR TYPE III.: MOLLUSCA.

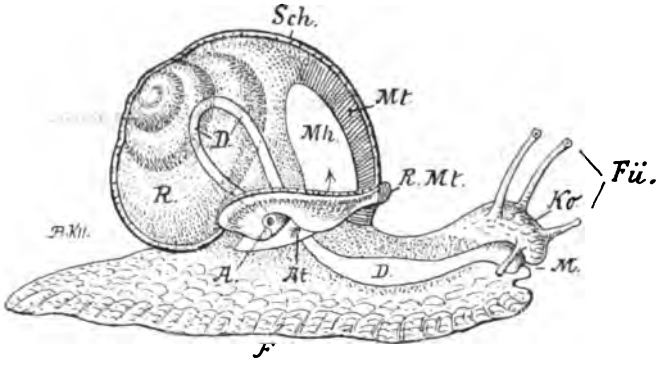
Bilaterally symmetrical, soft-bodied animals, without segmented limbs, with a ventrally-placed locomotor organ (foot), and a cutaneous fold (mantle) above the foot, which encloses the viscera, covers the respiratory organs (branchiæ, or lungs), and, as a rule, secretes a calcareous shell.

Ground-plan of Structure.—The Mollusca, which form the large and widely-branched third division of the animal kingdom, are, like vertebrates and arthropods, *bilaterally symmetrical animals* (see Part I., p. 2; this symmetry, however, disappears in the majority of the Gastropoda). They, however, neither possess an internal skeleton like vertebrates, nor an external one like arthropods. Their body, in fact, is of a *soft* nature (Mollusca = soft-bodied animal; Lat. *mollis* = soft), and is covered by a *slimy integument*. Hence these animals are for the most part inhabitants of the water, and, being wholly or partly supported by the surrounding water, neither require a firm and solidly-constructed body like land animals, nor an external body-covering for the purpose of preventing an excessive evaporation of water into the surrounding air (see Roman or vineyard snail).

Although the three principal types of the Mollusca—viz., the snail, the mussel, and the cuttle-fish—are of widely-different shapes, certain *essential* and *constantly-repeated features* may be recognised in their plan of structure. Since the nomenclature of the principal body parts has been borrowed from that of the land snails, we shall here confine ourselves to a detailed consideration of this group. These animals, when creeping extended along the ground, display on their lower or ventral surface a large muscular portion, by means of which locomotion is effected. It therefore functionally represents the limbs of vertebrates and arthropods, and is accordingly described as the *foot*. It supports the *body* of the animal, which encloses the viscera (intestine, liver, heart, and other organs, and in front is continued into a more or less distinctly separated *head*. The skin which envelops the body forms above the foot a dependent fold, which covers in a hollow chamber.

Digitized by Google

This fold, which partially or wholly envelops the body, is known as the *mantle*, or *pallium*, and the cavity as the *mantle cavity*, or *pallial chamber*. The latter is also known as the "branchial (or pulmonary) chamber," since it encloses the branchiæ, or functions as a lung. On its external surface the mantle secretes a shell, which protects the soft body of the animal. In regard to other forms of mollusc, see the respective illustrations. Most of the Mollusca propagate themselves by *eggs*.



STRUCTURE OF ROMAN OR VINEYARD SNAIL (DIAGRAMMATIC).

F., Foot; R., body; Ko., head; Fü., feelers; Mt., mantle; R.Mt., free edge of mantle; Mh., mantle cavity; At., respiratory aperture (the entrance to the mantle cavity is indicated by an arrow); Sch., shell; M., mouth; D., intestine; A., anus.

CLASS I.: SNAILS, SLUGS (GASTROPODA).

MOLLUSCA with an asymmetrical coiled visceral sac, well-developed head, and sole-shaped foot occupying the central portion of the ventral surface; mostly with a spirally-coiled shell, more rarely naked.

ORDER I.: AIR-BREATHING GASTROPODS (PULMONATA).

The Roman or Vineyard Snail (*Helix pomatia*).*

(Length of extended foot up to 3½ inches.)

A. Topography of Structure.

IN considering the structure of this animal, we must append the following additional remarks: The anterior termination of the grayish-white body

* This species is much larger than our common snails, and, although common in Germany, is only found is certain localities in England, *e.g.*, near Oxford. The structure of a common garden snail (*Helix hortensis*) is quite similar.

Digitized by Google

forming the *head*, with its two *pairs of feelers*, is indistinctly separated from the elongated *foot*. The latter supports the *shell*, which is yellowish-brown, with darker stripes, and encloses the *body* with the viscera. Along the edge of the shell a lighter-coloured yellowish membrane, the edge of the *mantle*, is visible. On its right side an opening appears and disappears periodically; this is the *respiratory aperture*, which leads into the mantle cavity, or respiratory chamber.

B. A Land Animal.

1. The Roman snail being a land animal, *its respiration is effected by a lung*, and the respiratory cavity is therefore a pulmonary chamber, the walls of which are traversed by a network of fine bloodvessels, through the thin walls of which the exchange of the respiratory gases is effected (see Part I., p. 6).

2. *Protection against Loss of Moisture.*—By reason of their naked, soft body, molluscs are conditioned for an aquatic life. The snail, therefore, being terrestrial in its habits, must, like land amphibians, be protected against the desiccating effect of the air and the parching action of the sun's rays (see Part II., p. 253). Accordingly, as in the last-mentioned group,

(1) The skin is covered with a *viscid mucus*, which retards evaporation (see also Section C, 1).

(2) Like them also, the snail is restricted to *a moisture-laden atmosphere*, and is only active on dewy nights, and on days when the air is saturated with aqueous vapour and the soil and plants are moist with rain. The vivifying effects of moisture on this and all other species of land snails may be shown by the following experiment: Put some snails in a vessel in a dry room, and notice that they at once withdraw into their shells, and remain for days, or even weeks and months, in this condition without giving a sign of life. If, however, we pour a little water into the vessel, so that the contained air soon becomes saturated with moisture, or if we sprinkle some of it over the animals, they will soon begin to stir, and in about an hour will be creeping about in the vessel.

(3) In dry weather and burning sunshine, the snail, like land amphibians, rests in a safe hiding-place, with this difference, that the snail builds the latter itself, and carries it about with it. During a prolonged drought the water of the mucus secreted by the edge of the mantle evaporates, and a membrane of papery thinness is formed (epiphragm), which still further protects the animal against an excessive loss of water (see also Section C, 5).

(*a*) *Shape and Size of Shell.*—If with a fretsaw we divide a snail

Digitized by Google

shell longitudinally, we see that it consists of a spirally-coiled passage, the inner surfaces of which unite in a hollow "central axis," or "columella," and which gradually widens out towards its aperture. This "house" is sufficiently spacious to include even the protrusible parts of the body. The retraction of these parts is effected by the contraction of a muscle attached to the columella, and extending to the anterior part of the creeping sole-like foot columellar muscle (see Section C, 1).

(*b*) *Components and Layers of the Shell.*—If a snail (or mussel) shell be placed in hydrochloric acid, it is almost entirely dissolved, carbonic acid gas being liberated at the same time. This shows that it consists for the most part of *calcium carbonate*, only a thin membranous structure retaining the shape of the shell being left. This consists of a horn-like substance similar to chitin, and called *conchiolin*. This substance enters more especially into the composition of the outer layer of the shell, the so-called *epidermis*, which hence protects the shell from being destroyed by water holding carbonic acid in solution, such water, as is well known, having the power of dissolving calcium carbonate. The central layer of the shell is composed of densely-packed prisms of calcium carbonate, and is known as the *prismatic* layer. The inner layer is composed of thin undulating lamellæ of carbonate of lime, and imparts to the shell the well-known nacreous (or mother-of-pearl) appearance (produced by interference of light), whence it is known as the *nacreous layer*. In the land snails, contrary to what we find in aquatic species, this layer is always very thin.

(*c*) *Formation of the Shell.*—The mode of production and growth of the shell may be distinctly observed in spring. At that time a thin, newly-formed ring is found at its margin, which gradually increases in hardness. It is imposed on the mantle (see Section A), and secreted by the latter, just as the chitinous shell of arthropods is secreted from the subjacent layer of the integument. (What differences, however, exist between these two formations?) The striation of the shell shows how it has gradually arisen. The lime necessary for its construction is taken in with the food, or obtained by the gnawing of calcareous rocks, the cement of walls, etc. The large quantity of this material which has annually to be secreted explains

(*d*) The *habitat* of this snail and allied species of land snails, which are only to be found in places where there is no dearth of lime. Hence districts with chalky or limestone soil, such as is the case with many vineyards, are frequently a veritable snail's paradise.

Digitized by Google

C. The Snail a Vegetable-feeder.

1. The snail creeps along in search of its food, which consists of leaves. Locomotion is accomplished by means of the muscular *foot* with its broad sole. If a snail is allowed to crawl up a glass pane, it will be seen that the sole of the foot is not lifted off from the surface of support (like the foot of a vertebrate, for instance), but *glides* slowly along. Only a few wavelike movements may be seen passing over it from behind forwards, something like cloud shadows over the earth. We further see that with each commencing wave the posterior end of the sole is drawn somewhat forwards, and with each concluding one the anterior end is extended somewhat forwards, while the rapidly-succeeding waves slowly impel the animal forwards. (How this peculiar motion is effected is not yet accurately known.)

Whether a snail be placed on loose or hard soil, on glass, wood, or any other material, it always creeps along at the same speed. This is undoubtedly a remarkable phenomenon, for we all know how the friction between the soles of our feet and the supporting surface varies according as we pass over different kinds of soil (*e.g.*, a rocky or sandy soil), and how a loose soil impedes our progress. This drawback the snail overcomes by means of the *band of slime*, or *mucus*, which the animal, as it were, spreads out upon its path. As we must all have noticed, this tough mucus adheres firmly to the surface of support, but separates with ease from the sole of the foot by which it is secreted. Hence, in the case of the snail we are concerned, not with friction between the sole and the supporting surface, but with that existing between the sole and the mucus. This latter friction, however, being always the same, the animal's speed of progress is consequently likewise invariable.

By means of this remarkable organ of locomotion the snail is able to ascend even vertical objects (trunks of trees, rocks, etc.), and to creep along the under side of horizontal surfaces (leaves). The sole in this operation acts something like a sucker (see cuttle-fish), or the adhesive pads which we have noticed in the foot of the fly. The viscidity of the mucus must also be considered in this connection.

2. Compared with mammals and arthropods, which are possessed of articulated limbs, the snail is a proverbially *slow-moving* creature (we talk of "snail's pace," etc.). Nor is there any necessity for rapid movement (any more than in the case of a caterpillar), the animal being a vegetable-feeder, able to obtain its food without great exertion. (Hence predaceous gasteropods are only able to capture slowly-moving animals.) The sluggishness of the snail, however, is attended by many dangers. (*Enemies:* Starling, thrush, shrewmice, etc.) It is, however, to some

Digitized by Google

extent neutralized by the possession of the hard *shell*. (Why cannot an active animal constantly carry its "hiding-place" about with it?)

3. The organs required for the discovery of food and of foreign objects generally are naturally to be found upon that part of the body which during motion is "to the front," viz., the head (see, however, Lamellibranchiata). These organs consist of two pairs of *feelers* ("horns"), of which the upper and longer pair carries the *eyes*, visible in the form of black dots. At the slightest touch these hollow tentacles are retracted, being introverted like the fingers of a glove; and it is only gradually and after carefully feeling about that they are once more protruded. The terminal knobs of the long feelers also serve as organs of smell.

4. The snail must also possess organs which will enable it to cut off very fine particles from plants (compare also Part I., p. 102). These organs and the manner in which they are employed may be best observed in a water-snail as it creeps along the glass side of an aquarium, feeding upon the green algæ with which this is covered. The *lips* of the mouth, previously closed, separate, and reveal a small brown plate, the so-called *jaw*. In addition to this, a tongue-like structure, covered with a membrane (composed of conchiolin), is protruded from the buccal cavity. When viewed under the microscope, this organ is seen to be covered with thousands of very fine backwardly-pointed teeth, so that it bears a remarkable resemblance to an elegant rasp or minute file, and is known as the *radula*. Every time that the snail presses the radula against the glass pane, moving it at the same time from below upwards, it scrapes off with it a small strip of the algous covering. When the food is of a harder nature (leaves and stalks), the *jaw* also is brought into action, cutting off such particles of the plant as are pressed against it by the radula. The mouth parts of the vineyard snail are constructed essentially on the same plan, and it feeds in exactly the same manner; but owing to its diet consisting exclusively of leaves, the mouth parts can only rarely be seen in action. It is, however, easy to discover the traces left by the radula (on the surfaces of leaves, especially distinct in fungi) and by the jaws (at the bitten edges). Indeed, by placing a number of these snails upon cabbage lettuces, the operations of the mouth parts may actually be distinctly heard. The jaws and radula may be easily obtained by boiling the head of a snail in a solution of potash. The intestine, which is continuous with the mouth, traverses the coils of the body, and terminates on the left side, close to the respiratory aperture.

5. In autumn the snail, by the aid of its foot, burrows in loose leaf-and-moss-covered soil, closes the aperture of the shell with a hard, calcareous lid (epiphragm), and enters upon a stage of *hibernation*.

Digitized by Google

Thus completely shut off from the outer world and protected against enemies and excessive evaporation (see Section B), the snail reposes until returning spring puts an end to the cold and scarcity of food. The animal now throws off the lid from the opening of its dwelling and reawakens to a new life.

6. It is only when it appears in large numbers that the vineyard snail commits any appreciable damage. In South Germany, Austria and the countries of Southern Europe, it is got rid of by a very simple and expeditious method, forming (in common with several other large species) a favourite article of consumption for fast-days.

D. Reproduction.

If a vineyard snail is discovered in the summer with only the upper portion of its shell projecting from the soil, it is a sure sign that we have caught it in the act of depositing its eggs. If it be lifted off the ground, we shall find that it has dug, by the help of its foot, a pit, often as much as 4 inches deep, in which it deposits thirty, forty or more white-coloured *eggs* about the size of a pea. These eggs are protected from injury by a parchment-like membrane impregnated with lime salts (see, however, freshwater snails), and prevented from drying up by the dampness of the soil. After the deposition of the eggs the female refills the pit, and if we examine it a few weeks later we shall already find the delicate transparent young.

Other Land Snails.

The shells of the various snail species living on land, like the vineyard snail, vary considerably in form and colour. In addition to these, however, we meet with some which retain only a minute rudiment of a shell within the mantle, which forms a shield-like structure covering the dorsal surface (naked gastropods, or slugs).

Examples of this group are the **Road Slug** (*Arion empiricorum*), which is frequently met with in woods and among bushes. It may attain to a length of 6 inches, and varies in colour from orange to black.

Another common species, the **Garden Slug** (*Limax agrestis*), frequently does much damage to crops and vegetables (strawberries).

A large number of pulmonate snails also live in fresh water, especially in calm ponds and pools. Their greenish-brown shells, which resemble the colour of the bottom and of aquatic plants, are accordingly much more delicate than those of most land snails. The same also applies to the bodies of the animals, and even to their eggs, which are enveloped in mucus (spawn, see common frog), and are glued to leaves and stones in sausage-like balls. In these snails the eyes are not placed on peduncles, and they possess only one pair of feelers, which are not introvertible.

Digitized by Google

In the **Pond Snails** (*Limnæa*) the shells are pointed, while in **Planorbis** they are flat like a dinner-plate. In Germany these snails are popularly known as "post-horns."

ORDER II.: GILL-BREATHING GASTROPODS (PROSOBRANCHIATA).

THE gill-breathing gasteropods are throughout aquatic in their habits.

Among the few freshwater species, the commonest is the **River Snail** (*Paludina*). Externally it bears a considerable amount of resemblance to the aquatic species of Pulmonate Gastropoda (which see), but the animal is capable of closing its shell with a lid, or operculum, developed on the posterior portion of the foot. Even inhabitants of inland districts are familiar with the rich variety of marine snails, whose many-coloured shells (freed from their superficial skin and polished) serve as ornaments or are turned into various articles of use, etc. The strength of the shell is invariably a sign that its former inhabitant lived on the surf or on shoals, where it was exposed to the full force of the waves.

This is seen in the case of the **Periwinkle** (*Litorina*), which is common everywhere on the shores of the North Sea and Baltic, and still more so in the case of the large foreign species, especially the gigantic **Wing-Shell** (*Strombus gigas*). This huge creature inhabits the coral reefs of the West Indian Islands. Its shell is much used as an ornamental border for flower-beds.

SHELL OF COWRY. (Slightly less than natural size.)
On the Left: Posterior view.
On the Right: Anterior view.

Hard as marble, again, are the well-known, variously-coloured shells of the **Cowries** (*Cypræa*), the shell of one of which, *C. moneta*, is, as is well known, used as money in the interior of Africa.

From a secretion of several Mediterranean species, which is white, but turns red when exposed to the air, a much-esteemed purple dye used to be prepared in ancient times. It was more particularly the **Spiny Murex** (*Murex brandaris*) which furnished this valuable substance.

ORDER III.: WINGED GASTROPODS (PTEROPODA).

THESE small molluscs are inhabitants of the open ocean, and, like many other free-swimming marine animals (see jelly-fish), are possessed of a jelly-like soft body of glassy transparency. In accordance with their habitat, the foot of these animals has been modified to a swimming organ. It consists of two lateral lobes which are moved up and down

Digitized by Google

exactly like the wings of insects. For this reason the fishermen of the Mediterranean call these molluscs by the descriptive name of "sea-butterflies." Many of these delicate creatures occur in enormous swarms, and hence form an important food-supply for many higher animals, especially fishes. With one species, *Clio borealis*, we have already become acquainted as forming the staple article of diet of the gigantic whalebone whales.

CLASS II.: BIVALVES (LAMELLIBRANCHIATA).

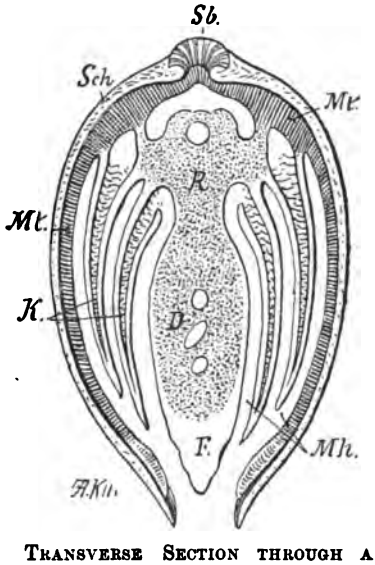
Bilaterally symmetrical molluscs with bivalve shells, head absent and wedge-shaped foot.

Fresh-Water or Painter's Mussel (*Unio pictorum*).

(Length up to 3½ inches.)

A. Structural Topography.

This mussel may be compared to a book. The two *valves of the shell*, which are movably united on the dorsal margin, correspond to the cardboard covers. The first and last leaves are represented by the cutaneous *mantle lobes* which lie closely adjacent to the valves of the shell (the whole inner space of the mussel between the mantle lobes being, accordingly, the *mantle cavity*). The second and third leaves from each end of the book are represented by the leaf-like *branchiæ*, and all the remaining leaves of the book taken together represent the body and foot of the mollusc. The fresh-water mussel is—



Transverse Section through a Lamellibranch (Diagrammatic)

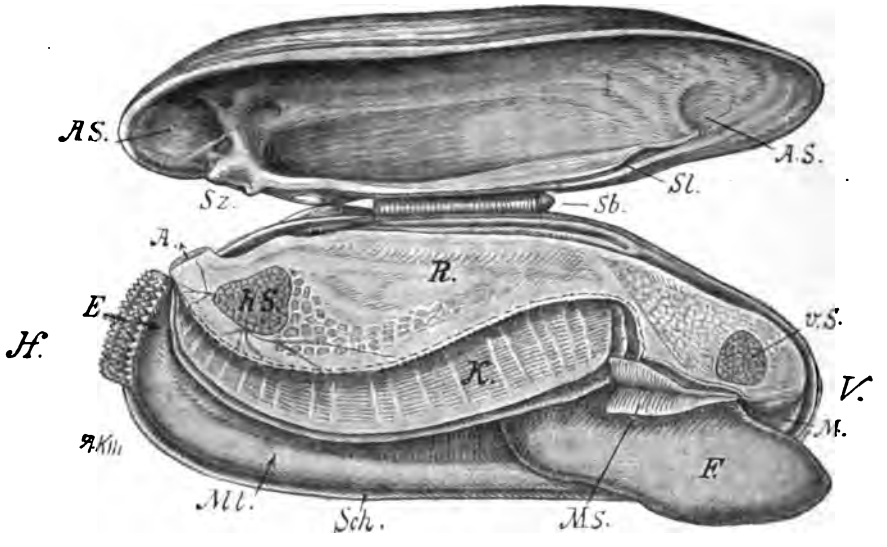
F., Foot; R., body; the white spots in the body (D.) represent the intestine in transverse section; Mt., mantle; Mh., mantle cavity; Sch., shell; Sb., hinge-line; K., branchiæ.

B. A Sessile Aquatic Animal.

In order to study its structure and habits, we place some specimens with water in a dish, the bottom of which is covered with gravel. (They may be found in any river. They were called painter's mussels because formerly their greenish shells were used for holding painters' colours.)

Digitized by Google

1. *How the Animal attaches itself to the Bottom.*—We may have to wait for hours before the mussels give a sign of life. At last the valves of the shell open a little, and a white body, the hatchet-shaped *foot*, protrudes through the gap. It extends itself more and more by degrees, and slowly bores its way into the gravel. Having obtained a purchase, it raises the animal upon the edge on which the valve opens (ventral edge), and gradually penetrates into the gravel, until, after some hours, only the pointed (posterior) end of the shell is left protruding. In this condition the mussel usually remains at rest at one and the same spot, and though by means of its foot it is able slowly to plough its way through the ground, it is as a rule a *sessile creature*.



FRESH-WATER MUSSEL LAID OPEN. (Natural size.)

The soft body lies in the left (lower) half of the shell; the right half of the mantle, which in the closed mussel lies upon the right (upper) half of the shell, has been separated along the dotted lines (- - -) in order to show the several parts of the body. V., Anterior, H., posterior, end of the animal; Sb., hinge; Sz. and Sl., teeth and ridges of hinge; Sch., margin of shell; Mt., left mantle lobe; F., foot protruded; Ms., the two right labial tentacles; at M., entrance to mouth; K., the two right branchiæ; R., body; v.S. and h.S., anterior and posterior adductor muscles of shell; A.S., places of attachment of adductor muscles on right valve of shell; E., left half of tubular afferent aperture formed by edge of left mantle lobe; A., efferent aperture.

2. *Protection.*—The otherwise defenceless animal is protected by a strong shell which encloses the body. Total seclusion from the outer world can, however, be only temporary, since the animal is obliged to breathe and to take in nourishment. Seclusion of the animal at the time of danger, and communion with the outside at other times, is rendered

Digitized by Google

possible by the division of the shell into two halves (valves), movable upon each other at the back, like the covers of a book. This movable 'back' is formed by an elastic band known as the *ligament*. The closure of the shell is effected by two muscles passing transversely across from one valve to the other, and firmly attached near the anterior and posterior ends of the valves (*adductor muscles*). Their places of attachment ('scars,' or muscular impressions) can be distinctly seen, and the force exerted by them is familiar to anyone who has ever tried to open a living lamellibranch (*e.g.*, an oyster). Further, any lateral displacement of the two valves of the shell is prevented by several tooth and ridge-like elevations of one valve which fit into corresponding depressions on the other valves, forming what is known as the *hinge*. In the dead mussel, the action of the adductor muscles ceases, and the valves of the shell gape, being drawn apart by the elastic ligament. The same, of course, happens in the living animal when it ceases to put these muscles into action.

The shell is formed and grows, as in gastropods (see p. 430), by secretion, from the *mantle* which forms a soft lining membrane upon the inner surfaces of the valves, and surrounds the whole body.

3. *Respiration and Nutrition.*—In a fresh-water mussel which is left entirely undisturbed, we notice at the posterior end, between the valves of the shell, two apertures—a lower, larger one surrounded by tentacular processes, and an upper, smaller one. If we repeat the experiment made in the case of the crayfish (see p. 418), by bringing a finely-powdered pigment near these openings, we shall see some of the pigment particles being drawn in by the lower aperture disappearing in the interior of the animal, but after a short while being once more expelled from the upper opening. *Hence a current evidently enters the animal through the lower opening, and makes its exit by the upper one.*

(*a*) *How this current is originated* we can discover by means of the microscope. If we examine a small portion of a branchia, or of the inner mantle surface of a freshly opened animal, under a fairly high magnifying power, we shall see that the surface of these parts is covered with millions of extremely fine filaments, moving rhythmically like corn waving in the wind (*cilia*). If now we introduce into the water containing our fragment a small quantity of the pigment, we shall further see that the movement of the cilia is such as to drive the grains of pigment all in *one* direction. In exactly the *same manner these cilia* produce the *current of water which traverses the whole mantle cavity.*

(*b*) It is easy to understand the *importance of this current* when we reflect that the mussel is a sessile creature. For respiratory purposes, it requires a constant renewal of the water which bathes the gills, and it also requires food which, in the absence of an effective organ of loco-

Digitized by Google

motion, it cannot, like a snail, for instance, go to seek for itself. *Both these requirements, therefore—viz., water rich in oxygen and its necessary food—are carried to it by the current.*

To the blood which streams through the leaf-like gills, this current gives up its oxygen in exchange for carbonic acid gas, whilst the minute food particles which it contains (microscopic plants and animals, decaying animal and vegetable substance accumulated in and floating on the top of the mud) are conveyed to the so-called *labial tentacles*—two small, leaf-like processes on each side, right and left, of the *mouth*. These processes also are covered with cilia, which, by their vibrating movements, conduct the food particles to the mouth, which lies somewhat concealed in front of the foot.

The water, after being thus deprived of its useful constituents, is next expelled, together with excreted matters, through the upper smaller opening at the posterior end of the animal, which is accordingly called the *efferent aperture*, in distinction from the other opening, which is described as the *afferent aperture*. Both openings are gutter-like grooves of the mantle edges, which by apposition form small tubes. If the edges of the mantle be touched ever so lightly, they at once contract, showing that they are extremely sensitive. The tentacles at the *afferent aperture* also are highly sensitive to tactile impressions. (Why this portion of the body especially?)

(*c*) *Organs absent in the Fresh-water Mussel.*—As it lives exclusively upon microscopic particles, the fresh-water mussel lacks all those organs which are concerned in the division of the food—*e.g.*, *jaws* and *radula*—such as we find in gastropods. Moreover, as the animal does not go in search of its food, it is devoid of *feelers*, *eyes*, and likewise of a *head* carrying these organs. (Some lamellibranchs, however, which lead a more active life, are provided with a fairly large number of eyes developed on the projecting edge of the mantle.)

(*d*) *Why the Fresh-water Mussel is restricted to an Aquatic Existence.*—The atmosphere does not contain floating food particles in sufficient quantity to provide nourishment for an animal. The number of microscopic animals living in the air is inconsiderable, whilst microscopic plants are entirely absent, and such decaying animal and vegetable substances as are whirled about by air-currents soon fall to the ground again. Nor would it be possible for a sessile animal to produce in a rare fluid like the air an eddying current for the conveyance of food materials. On the other hand, these conditions are exactly reversed in water, which is so much denser than air, and so rich in suspended food materials. Hence fixed, or, at any rate, to a large extent, sessile animals like the fresh-water mussel can only exist in water, and accordingly all

Digitized by Google

of them breathe by *gills* or *branchiæ*. (Contrast with pulmonate gastropods.) Between the leaves of these gills, also, the *larvæ*, after their escape from the *eggs*, pass through the earlier stages of their development. They next attach themselves to fish and tadpoles, which they do not leave until some months later, when they have developed into the perfect bivalve.

Other Lamellibranch Species.

In ponds we frequently meet with a species of bivalve, the so-called **Pond Mussel** (*Anodonta cygnea*), which reaches a length of 7½ inches. Inhabiting as it does calm water, its shell is usually thin, and the "hinge" toothless.

On the other hand, in the **Fresh-Water Pearl Mussel** (*Unio margaritifer*), which inhabits rapid mountain streams, we meet with a strong hinge provided with large teeth. This mussel is found in Northern Europe and America, and, like other fresh-water mussels, furnishes pearls (hence name). These owe their origin to the introduction of grains of sand or similar bodies between the mantle and the shell, which act as an irritant on the pallial membrane, and hence become surrounded by nacreous layers. (Compare with the encystation of the Trichina.)

The pearls of fresh-water mussels are not to be compared either in size, brilliancy or colour with those furnished by the true marine **Pearl Oyster** (*Meleagrina margaritifera*). This animal lives in colonies in different parts of the Indian Ocean on banks at a depth of not more than from 27 to 54 feet from the surface. The pearl fishery is carried on by native divers. These, in order to get rapidly to the bottom, let themselves down with a stone, gather as many oysters as they can in the short space of a minute—for they are unable to stay longer than this below the water—and are then drawn up by a rope. The oysters are thrown in heaps and allowed to die, and it is only after they have completely decayed that they are examined for pearls. A closely-allied species on the coasts of the West Indian Islands also furnishes valuable pearls. The shells of many of the pearl-producing bivalves, including those of the fresh-water pearl mussel, are used for the production of many kinds of ornamental articles, buttons, etc.

Many lamellibranchs, again, are important as food. This especially applies in Northern and Western Europe to the **Common Oyster** (*Ostrea edulis*). The larva of this species for a time swims about freely in the sea (dissemination of the species), but finally settles permanently on sand, stones, or the shells of other molluscs, one of its valves (the left) becoming, in a very short time, firmly cemented to the supporting surface. In this valve, which constantly increases in thick-

Digitized by Google

ness, the animal lies as in a dish, the lid of which is formed by the shallow and thinner upper valve. In the motionless oyster there is little difference between anterior and posterior ends; the current of water flows in along the whole ventral edge of the shell, and the foot, which has become useless, completely atrophies. These conditions make it easy to understand that oyster colonies—"oyster banks," as they are called—can only be formed on hard ground, washed over by tidal currents, which convey to the sessile animals their necessary food. In Germany the deep channels on the west coast of Schleswig-Holstein are the only situations adapted for the habitat of the oyster. In the Baltic it is entirely absent. The oyster fishery is carried on by means of dredges.

Another edible bivalve, the **Sea Mussel** (*Mytilus edulis*), attaches itself in a different manner. This animal, like many other bivalves (*e.g.*, the pearl oyster; see above), possesses in its foot a gland which secretes a viscid fluid. When this comes in contact with water it at once hardens into threads (byssus), by which the animal attaches itself to the supporting surface. Thousands of these beautiful blue-shelled bivalves may often be seen attached to the piles of piers, etc. On the coast of France mussels are cultivated on stakes and hurdles fixed in the mud.

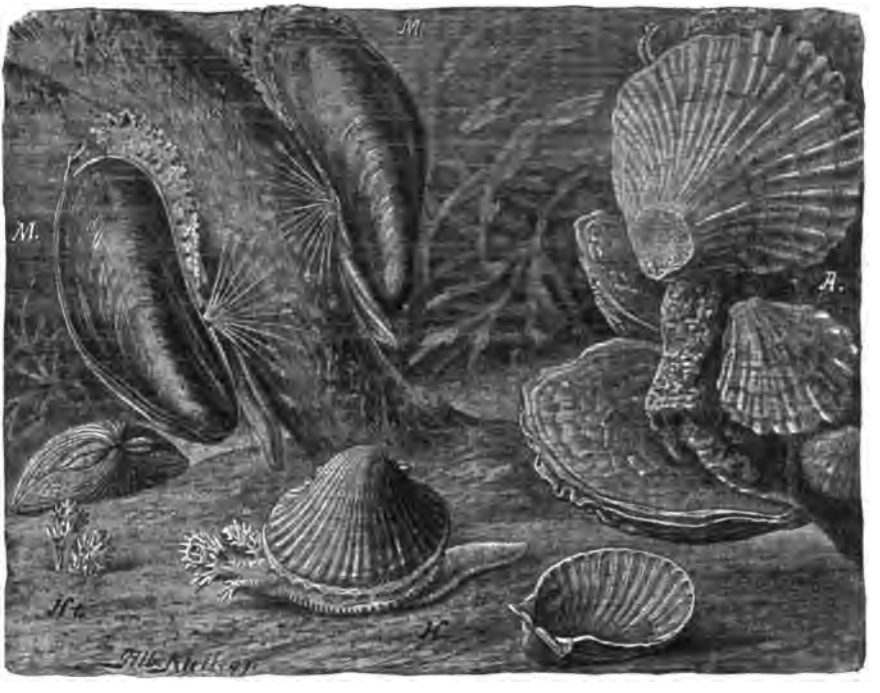
Another species of similar form, the triangular *Dreissena polymorpha*, which also attaches itself by a byssus gland, has been introduced by ships and rafts from the Black Sea into a very large number of European rivers.

Another species, the **Cockle** (*Cardium edule*), is much consumed in Southern Europe, Britain, and Holland. This mollusc is found on all the European coasts, and sometimes in such quantities that the shells are burnt to make lime, or are used as road-metal. The animal is fond of completely burying itself in sand or mud. As it is necessary, however, that it should remain in communication with the water (why ?), the edges of the mantle coalesce at the afferent and efferent orifices, and form tubes which project above the sand or mud into the water. The animal, however, remains to some extent freely movable, and by means of its foot is capable of moving forwards by jumping. Hence the siphonal tubes remain short, whereas in those species which are permanently sessile in the mud they often attain to a considerable length and become concrescent. This is seen in the **Boring-Shells** (*Pholas*), which burrow deep down into wood, and even into solid rock. This they accomplish by means of their foot and shell, the anterior end of which is rough, like a file. Their elongated shape assists the animals in penetrating these objects. They are, however, unable to leave their self-created

Digitized by Google

prison, owing to continued growth, but in return are well protected against enemies. Hence the shells also may be so much reduced in size as sometimes not completely to enclose the body.

These features are displayed in a still higher degree by the **Ship-Worm** (*Teredo navalis*). This animal has more the appearance of a



MARINE LAMELLIBRANCHS. (Natural size.)

M., M., Sea-mussels, sessile, on a submerged tree-trunk, with foot protruded and byssus threads. The "crimped" structures are the mantle-edges protruding between the valves. A., Oysters of different ages, sessile, upon a rock (these figures seem to be wrongly drawn, the oysters are represented as attached by the right or flat valve instead of the left); H., cockle with protruded foot and fringed incurrent and excurrent siphonal tubes; at H1, one of the latter buried in the sand, with only the two tubes left protruding; next to it another cockle with the shell closed, seen from the dorsal or hinged side, and on the right one of the valves of a cockle-shell.

worm (name) than of a mollusc, and bores long galleries in piles and other woodwork. It often does great damage by destroying wooden structures in harbours and breakwaters, and also by burrowing into the hulls of ships, which on that account are covered over with copper.

Digitized by Google

CLASS III.: CUTTLE-FISHES (CEPHALOPODA).

PERFECTLY bilaterally symmetrical molluscs with distinct head; with arms which surround the mouth, and are provided with suckers; with muscular lobes, the lateral margins of which are applied to each other behind, and mostly fuse so as to form a funnel.

ORDER I.: DIBRANCHIATA.

The Common Cuttle-Fish (*Sepia officinalis*).

(Length without tentacles up to 12 inches.)

A. Topography of Structure.

THE cuttle-fish possesses a large *head* definitely distinguished from the body, and furnished with a number of so-called "arms" (Cephalopoda = head-footed) which surround the mouth, and on their inner surface are covered with *suctorial discs*. The head bears on each side a pair of very large *eyes*. The body is flattened, and carries on each side an integumentary *fin*. On the dorsal side the skin encloses a plate-like *shell* of loose texture—the so-called cuttle-bone. On the ventral surface the mantle forms the *mantle cavity*, or *pallial chamber*, from which protrudes the perforated *foot*, or so-called *funnel*. Thus, in its structure the cuttle-fish presents essential differences from the gastropods and lamellibranchs. Nevertheless, as in the case of the last-named groups, we discover the same intimate connection between its—

B. Structure, Habitat, and Mode of Life.

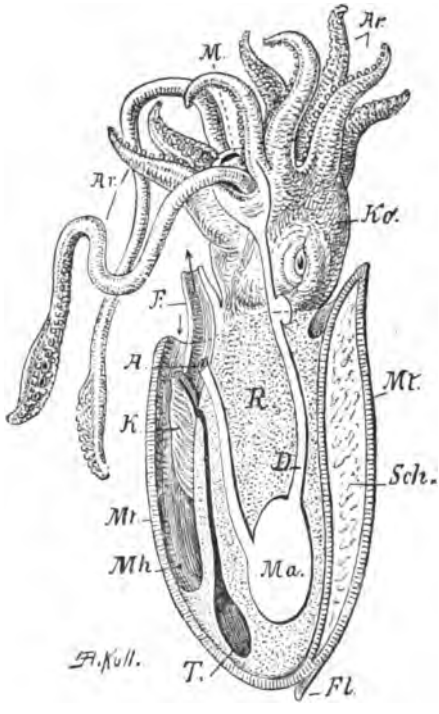
1. The cuttle-fish is an inhabitant of the sea. It is found abundantly everywhere on the coasts of the Mediterranean and Western Europe, and in many places forms an important object of the fishing industry. (The flesh is eaten; the contents of the ink-bag—see Section 5—furnish an important painter's colour, viz., sepia; and the cuttle-bone is used as a polishing material.) The animal is also occasionally found in the North Sea.

2. *Respiration.*—In accordance with its habitat, the cuttle-fish breathes by gills, which form two delicate plume-like structures, lodged in the *branchial* or *pallial cavity*. The water enters this cavity at the free edge of the mantle, bathes the gills, and is again expelled, together with the fæces and the excretions of the kidneys, which, as well as the intestine, open in the mantle cavity. These various materials are expelled by the tubular *funnel*, which protrudes from the mantle cavity

Digitized by Google

like a chimney. For this purpose the mantle cavity must, of course, be tightly closed, which is effected by the edge of the mantle being firmly apposed to the body, whilst two stud-like prominences of the inner mantle surface are pressed into corresponding depressions of the body.

3. *Locomotion.*—When water is violently driven through the funnel, the effect of the recoil thus produced drives the animal rapidly *backwards*. (Why is such a connection between respiration and locomotion only possible in the case of aquatic animals? Compare larva of dragon fly.) This backward movement is further assisted by the animal alternately expanding and rapidly striking together its arms, whereby a second forwardly-directed current of water is produced. By this action of the arms alone, too, the animal is able rapidly to swim backwards (see Section 5). Its *forward* movements, on the other hand, are slow, and are effected by undulatory (screw-like) motions of the fins (see Section A), or by rowing with the help of the four lower *arms*.



STRUCTURE OF A CUTTLE-FISH (DIAGRAMMATIC).

Ko., Head; Ar., arms; M., mouth; R., body; Fl., a portion of the fin; Mt., mantle; Sch., shell (cuttle-bone); F., perforated foot, or funnel; Mh., mantle cavity; K., branchia; the course of the inflowing and outflowing water is indicated by arrows; D., intestine; Ma., stomach; A., anus; T., ink-bag.

4. *Food.*—The cuttle-fish is of predaceous habits, its food consisting chiefly of fishes and crustaceans. It is interesting to inquire how it can capture these, for the most part, rapidly-moving animals, seeing that it can only slowly move in a forward direction. (Why is its rapid backward motion of no importance in this respect? See crayfish.)

(*a*) The cuttle-fish when in search of prey lurks motionless at the bottom of the sea, to which it can adapt the colour of its body (see p. 253) to such a degree that frequently it is impossible to discover the animal even in an aquarium. (In connection with this capacity is also the peculiar play of colours noticed in this and other cephalopods. When the animals are irritated or excited in any other way, yellow, red, blue, and other colour tints pass

Digitized by Google

rapidly over the body, something like the fugitive red blush on the human face.) The cuttle-fish resorts to further means of rendering itself unrecognisable by covering its body with sand and pebbles. (Compare with plaice.)

(*b*) Being, however, unprovided with articulated limbs, the mollusc requires organs for capturing and holding fast its fugitive prey. This is accomplished by the ten *arms* attached to the head. Two of these, which are considerably longer than the rest, are thrown out like lassos, and by means of their numerous suckers apply themselves so tightly to the body of the prey that escape is no longer possible. These tentacles next, by shortening, bring the victim within the grasp of the eight shorter arms which encompass it, and hold it fast by hundreds of suckers. Each of the latter is carried like a berry upon a small stalk, or peduncle, and consists of an external ring, strengthened by an internal cartilaginous support and a central muscular piston. When the ring is tightly applied to an object and the piston retracted, a vacuum is produced underneath the latter, so that the disc adheres to the object like a cupping-glass. (Mention some physical experiment based on the same principle.) By the aid of these sucking-discs the cuttle-fish is also able to progress, walking upon its arms, with its head directed downwards (cephalopod, *i.e.*, head-footed).

(*c*) The cuttle-fish cannot swallow its prey, and is accordingly provided with powerful *jaws* and a *radula* in the buccal cavity, like gastropods, for the purpose of dividing it into smaller pieces (see p. 432).

(*d*) Closely connected with its predatory mode of life are also the extraordinarily large, keen-sighted *eyes* of the animal, which are constructed very similarly to those of vertebrate animals (see Part I., p. 12; and contrast with gastropods and lamellibranchs).

5. *Enemies.*—The predaceous cuttle-fish is itself actively pursued by large fish and toothed whales. With two important means of protection against these—viz., its capacity of rapidly adapting its colour to the bottom and of swiftly hurrying backwards through the water—we have already become acquainted. When both these means fail it, the animal can still fall back upon a third and extremely remarkable method of escape: it discharges into the mantle cavity a *blackish-brown colouring matter*, expels the water thus discoloured through the funnel, and thus envelops itself in a dark cloud, in which it vanishes from the sight of its pursuer. This colouring matter (sepia; see Section 1) is produced in a gland, and stored up to be used when required in the so-called *ink-bag*. (Why is the name "cuttle-fish" only half correct?)

Digitized by Google

Other Cephalopoda.

All the cephalopods are predatory animals and inhabit the sea. In addition to the ten-armed species (**Sub-Order Decapoda**), there is also a large number in which the two long tentacles are absent (**Sub-Order Octopoda**). Among the latter, the **Common Octopus**, (*Octopus vulgaris*), which is found on the coasts of Southern and Western Europe, is not only the commonest, but also the largest and strongest, species. This animal between the tips of its extended arms, which far exceed in length the saccular body, sometimes measures more than 10 feet. It lurks in wait for prey in rock caverns or among stones, surrounded by the shells of the molluscs and crustaceans which have formed its meal. In absence of a suitable hiding-place, the creature constructs one for itself by collecting stones with its arms. Whilst on the watch for prey, the skin, which is at other times smooth, appears wrinkled, and the colour exactly resembles the rocky nest in which the creature is hiding. The arms embrace the unsuspecting victim like so many snakes. At their base they are united by webbed membranes, so that their basal portion resembles a sack, in which the prey is firmly and securely shut in. Remains of the internal shell of a family of decapods long since extinct, the **Belemnites**, have been preserved in a fossilized condition, being popularly known as "thunderbolts."

Opposed to the above-named group of cephalopods, all of which are provided with two branchiæ, we have another much smaller division, in which four branchiæ are developed (**Order II.: Tetrabranchiata**).

The only living representative of this order is the **Pearly Nautilus** (*Nautilus*). The animal is an inhabitant of the Pacific and Indian Oceans, and constructs a shell coiled into a spiral like that of a snail. This shell, however, is divided into a number of chambers by transverse partitions, of which fresh ones are constantly formed as the growth of the animal proceeds. The foremost of these chambers is occupied by the animal; the rest are filled with air, and traversed by a cord-like membranous process of the body (the siphuncle). The weight of the shell is much diminished by the air in the chambers. The Nautilus lives near the bottom, and has only occasionally been taken at the surface.

An extinct order of cephalopods, the **Ammonites**, the fossilized shells of which have come down to us, were animals similar to the nautilus in all essentials of form and structure.

Digitized by Google

DIVISION OR TYPE IV.: WORMS (VERMES).

Bilaterally symmetrical animals without articulated limbs, and with the body invested by a dermo-muscular tube (see earth-worm).

CLASS I. SEGMENTED WORMS (ANNELIDA).

Body divided into a large number of similar rings, or segments.

ORDER I.: BRISTLE-WORMS (CHÆTOPODA).

The Earth-Worm (*Lumbricus terrestris*).*

(Length up to 12 inches.)

A. Body Covering.

The body of the earth-worm is invested in a *soft* and *naked skin*, which therefore, like that of the vineyard snail (see p. 429), is always covered with a *slimy fluid*. Hence, like the snail, the earth-worm can only exist in a *damp atmosphere*. For this reason, in the daytime it only comes to the surface when the weather is dull, and at night when there is dew; but it is specially abundant during rainy weather. At other times the animal remains in concealment in the *damp soil*, and hence it is never met with in a dry, sandy soil (see also Section F).

B. Respiration.

If, while a garden is being dug up, an earth-worm happens to get upon a firmly trodden path, so that it is unable to burrow its way into the soil again, it soon perishes, for, owing to the great loss of moisture, its respiration, which is carried on by the whole delicate and moist surface of the body (see Part II., p. 274, Section D) is soon arrested.

C. Form of Body.

The body of the earth-worm is much elongated. Hence the tubular, mostly vertical passages which it burrows underground are of no great

* This Linnæan species is now subdivided into several separate species.

Digitized by Google

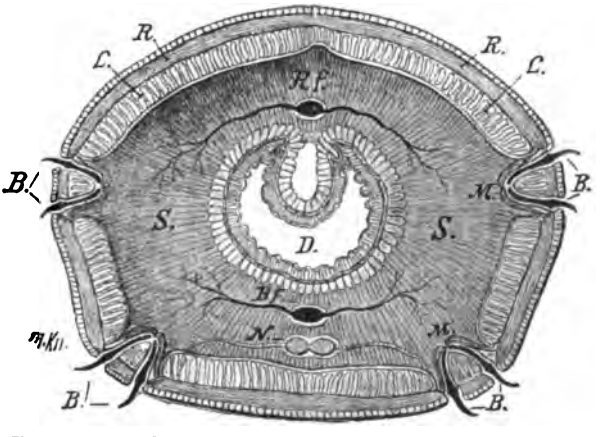
width. (How far is this an advantage to the animal? Compare with other burrowing creatures.) These runs as a rule only extend to a depth of about 20 inches, but in exceptional cases to as much as 6 feet. Owing also to its "vermiform" shape, the animal meets with comparatively little resistance in the dense medium in which it lives. (Compare with fishes, p. 266.)

D. Colour.

As in most animals living underground (examples), the skin in many worm species (not all) is colourless. The fleshy colour of the worm is due to the blood showing through the body wall.

E. Motion and Locomotor Organs.

(*a*) The earth-worm progresses by stretching and advancing the fore-part of its body, and then drawing the posterior portion of the body up to it. How are these movements accomplished? They are unlike those of snakes or of any other animals. They are explained, however, by the peculiar structure of the skin. If an earth-worm which has been killed in weak spirit be opened with fine scissors, we shall be struck by the remarkable thickness of its "skin." On a closer examination, however, we shall see that we are here not merely dealing with the skin, but with a strong muscular mass intimately fused with the skin, the so-called *musculo-cutaneous tube*. The muscular portion of this tube is itself composed of two layers: an outer layer, which surrounds the body like a ring (annular muscle layer), and an inner one, in which the muscular fibres run longitudinally (longitudinal muscle layer). If the first of these layers contracts at any particular spot, the body will there become thinner, or, in other words, be stretched in a longitudinal direction; if next the longitudinal fibres



TRANSVERSE SECTION THROUGH BODY OF EARTH-WORM (SOMEWHAT DIAGRAMMATIC).

The section is taken in such a position as to show the transverse septum, S., between two adjacent body segments; R. and L., annular and longitudinal muscular layers; B., setæ; M., muscles which move the setæ; D., intestine; Rf. and Bf., dorsal and ventral bloodvessels, from each of which two branches are given off; N., the two principal nerve chords, each giving off two nerve branches.

Digitized by Google

contract, the effect will be to again shorten the body, and in this manner the movements of the body above described are accomplished.

(*b*) The great extensibility and pliancy of this locomotor apparatus is still further increased by its subdivision into a large number of *rings*, or annular segments (see p. 308)—Annelida, *i.e.*, ringed worms. Corresponding to this external annulation we also find the internal body cavity subdivided by delicate transverse septa into a series of chamber-like segments, corresponding to the body rings.

(*c*) Motion is further facilitated by the action of minute bristles, or *setæ*, eight of which are found upon each body segment, and which are arranged over the body in four longitudinal rows (two lateral rows and two on the ventral surface). If one of these worms be carefully drawn through the tips of the fingers from behind forwards, the setæ may be distinctly felt, while their rustle may be clearly heard if the animal is allowed to creep over some paper. They are inserted in the skin, and are protruded by the action of special muscles, again retracted, and in locomotion are moved from behind forwards like legs. Owing to their shortness, they are unable to raise the body (especially as this is devoid of a skeleton) from the surface of support; in fact, the body is really dragged along the ground, so that progress is necessarily slow. (Compare p. 308.) Hence the track of the earth-worm may be seen on soft, damp soil as a distinct furrow. These setæ also act as "climbing-irons," by means of which the worm holds fast to the walls of its tunnel and climbs up and down in it. Since the soft body of the animal is in the earth supported on all sides (somewhat like that of an aquatic animal), these movements are accomplished with the greatest ease.

(*d*) *The manner in which the earth-worm bores its runs* is easily observed by placing one of these animals on loose soil. It will then be seen to extend the anterior (cephalic end) of its body, so that it becomes quite thin and pointed; next, by means of the very sensitive first body segment, or *cephalic lobe*, it feels about for a crack or scratch in the ground, into which it pushes the anterior end of its body, which at the same time swells considerably and forces apart the soil in the manner of a wedge. The swelling is caused by the muscular *pharynx*, into which the *mouth* opens on the ventral surface of the second body segment. In hard soil which it cannot penetrate by burrowing, the earth-worm digs its runs by gnawing. It takes up the soil with its mouth, passes it through the intestine, and returns it by the terminally placed anus to the surface in the form of the well-known worm-castings.

Digitized by Google

F. Food.

This manner of motion at first sight seems very wonderful (reminding one of the fairy legend of the Castle of Indolence), but in reality is not at all strange when we consider that the food of the earth-worm consists of animal and vegetable substances which are contained in the soil, and for the purpose of obtaining which it is obliged constantly to fill its intestine with earth. For this reason, too, the earth-worm always selects for its habitat a soil which is rich in humus. The leaves, blades of grass, etc., also, which at night it drags down into its runs, form after they have decayed a very acceptable nutriment.

G. Sense Activities.

If a worm is surprised while visiting the surface of the soil, even the slightest tremor of the ground is sufficient to make it escape rapidly into its hole. This points to the possession of a very fine *tactile sense*. Again, though eyes are absent, as is the case in most animals living underground, the earth-worm is not *insensitive to light*, for if the light of a lantern be thrown upon it it at once retreats. It is evidently also endowed with *taste* and *smell*, for it shows a decided preference for certain kinds of food (cabbage-leaves, carrots, etc.), and knows where to find these, even from a considerable distance.

H. Reproduction.

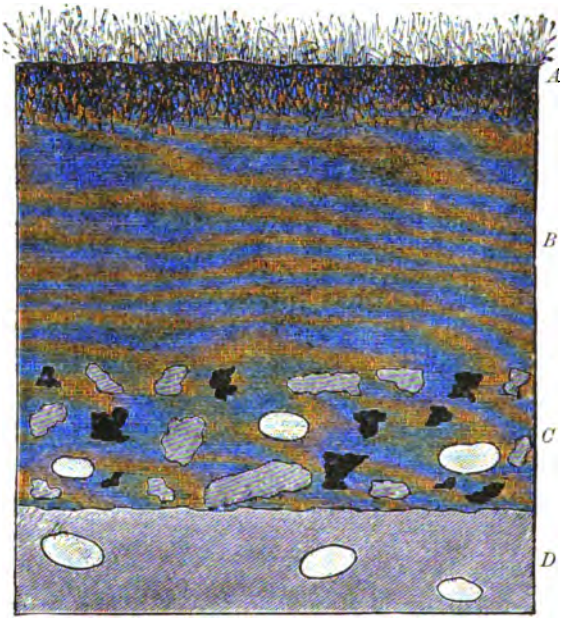
Reproduction takes place by *eggs;* these are surrounded by a mucous envelope, which hardens on exposure to air. This mucus is secreted by glands situated on a number of rings at the end of the anterior third of the body, causing a considerable swelling of this region, which is known as the "clitellum."

I. Importance of the Earth-Worm in the Economy of Nature.

The important part played by this despised creature in the economy of Nature will be evident from its mode of life. We saw how daily it takes into its body a small portion of the rich, humus-laden soil, and again discharges the undigested remainder upon the surface. When we next reflect that even in a small garden the same thing is done by thousands of worms, we shall understand how in the course of only a few years the whole top covering of mould must pass through the intestines of these tiny creatures, while in the course of millions of years this must have occurred thousands of times. The feeble worms slowly carry the lower strata of the soil to the surface, and cause the upper

Digitized by Google

ones to vanish below. Thus they plough up the ground like the farmer. Earth-worms, further, constantly loosen the soil by digging out new passages to replace their old ones, which are constantly falling in. By bringing the separate constituents of the soil constantly in contact with fresh air and water, they bring about their disintegration and decomposition. While thus preparing the soil, they also, as it were, manure it by dragging leaves and similar substances down into their runs, and finally they thoroughly mingle all these different materials like a gardener who wishes to produce a good rich garden mould. Where it occurs in enormous quantities, the earth-worm naturally may become *destructive* by pulling all the young plants down into its runs (see p. 72). It is, however, incorrect to charge it with gnawing at the roots of young plants, for in the absence of teeth it is difficult to see how it could accomplish this.



SECTION THROUGH UPPER STRATUM OF A FIELD which fifteen years previously, when a waste, swampy piece of ground, was ploughed, drained, and thickly strewn with burnt marl and cinders (one-half natural size). Through the agency of earth-worms, in the course of years so much soil was conveyed to the surface that a layer about 3 inches thick of arable soil (A and B) was formed, while the marl and cinders sank to a depth of from 3 to 4½ inches (into the layer C). The stratum of subsoil (D), consisting of peaty sand, which was not disturbed, contains (like the layer C) some rolled pebbles of quartz.

Hence there is every reason for protecting so remarkably useful an animal, which, moreover, unprotected by defensive weapons, is exposed to the attacks of an innumerable host of enemies.

Allied Species.

Owing to the nature of their body, all other worms require a moist habitat. Hence many live in water. The nearest allies of the earth-

Digitized by Google

worm, viz., the variously-shaped Polychæta, are for the most part marine. One species, the **Lug-Worm** (*Arenicola marina*) is found and caught in millions off our coasts, and much used for bait. This worm burrows in the sand of the sea-shore, and resembles the earth-worm, being, however, provided with red external gills.

Anyone who has visited a sea-water aquarium must be familiar with the tubes found encrusted upon mollusc-shells, stones, etc. These are constructed by **Tubicolous Annelids** (*Serpula*; see illustration, p. 462) for the protection of their soft bodies. (Compare with caddis flies.) The animals climb nimbly up and down these tubes like an earth-worm in its run, while above the aperture of the tubes they elevate their plume-like and usually beautifully-coloured gills, which are also used for producing a current of water (see p. 498, Section *d*).

ORDER II.: LEECHES (HIRUDINEA).

The Medicinal Leech (*Hirudo medicinalis*).

(Length up to 8 inches.)

The medicinal leech *lives at the bottom of ponds and lakes*. Its colour is very variable, but mostly greenish-brown. (Compare with other bottom-living animals.) Like the majority of free-living worms, it possesses *eyes*, which are visible as dark dots upon the anterior body rings. It is a *parasite*, its food consisting of animal juices, which during its youthful stage it derives from snails, tadpoles, and other cold-blooded creatures, but in its adult condition from warm-blooded animals as soon as these enter its habitat (name). As, however, the former of these animals are soon sucked dry, whilst the latter leave the water soon after entering it, it is necessary that the leech, unlike sessile parasites (see tape-worm), should be endowed with the power of free *locomotion*. It swims very nimbly by undulatory movements of its *much-flattened* body, and creeps by means of the two *suckers* (see cuttle-fish) developed on the anterior and posterior ends of the body, somewhat after the manner of the Looper or Geometer caterpillars (which see). These suckers are also indispensable to the animals as organs for retaining its captured prey. At the bottom of the anterior sucker, which during suction acts like a cupping-glass, is placed the three-cornered *mouth*. By opening this slightly we obtain a view of the apparatus by which the leech gains access to the body juices of its host, viz., three plates, or *jaws*, radiating from a point, the curved outer edges of which are sharply serrated. Thus, each jaw represents, as it were, a portion of a minute circular saw, and also acts

Digitized by Google

as such. After the skin has been thus sawed through, producing the characteristic (triradiate) wound, the intestine, which is very extensile and provided with lateral cæcal pouches, is filled with blood to such an extent that the leech frequently acquires four times its natural circumference. It is, however, absolutely necessary that the animal should be capable of thus taking in at once so large a supply of blood, which may last it for a considerable time, for it may be years before it gets another opportunity of thus "bleeding" a warm-blooded animal. It is to this peculiar manner of feeding that the leech owes its *application in medicine* (hence called medicinal leech). In the summer the adult females leave the water, bury themselves in the damp earth near the bank, and there deposit a number of eggs, protected by an envelope of mucus, which hardens in the air.

A much more frequent inhabitant of our waters is the so-called **Common** or **Horse Leech** (*Aulostoma gulo*). In this species, however, the teeth of the jaws are blunt, and cannot cut through the thick skin of vertebrate animals.

CLASS II.: ROUND OR THREAD WORMS (NEMATHELMINTHES).

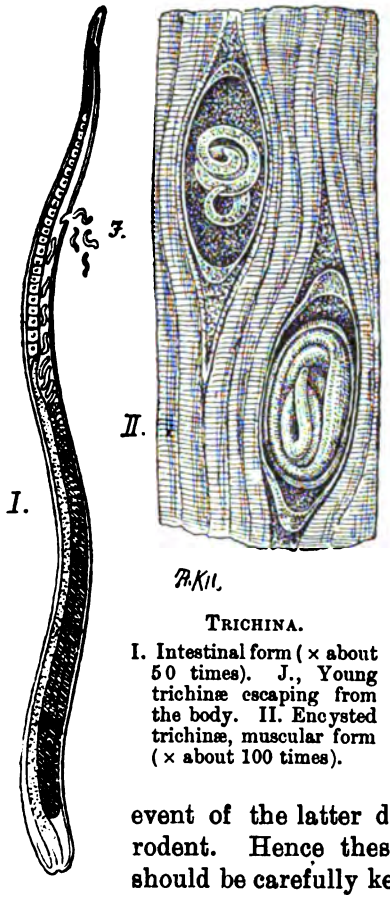
Body cylindrical, not divided into rings.

The Trichina (*Trichina spiralis*).

In 1835 an English student discovered in the muscles of a human body, spirally coiled up, white, eyeless (compare with tape-worm) worms about $\frac{1}{12}$ inch long. They were enclosed in a small capsule or cyst, and were called trichinæ. Afterwards they were also discovered in the muscles of the pig, rabbit, rat and several other animals; but the question how they had got to these parts was not easily answered. It was not until the year 1860 that three German naturalists, by feeding pigs and rabbits with meat containing trichinæ, succeeded in throwing some light on the life-history of this dangerous worm. This, briefly, is as follows: If a portion of meat containing encysted trichinæ is eaten by man or another animal, the cyst is dissolved by the gastric juice. The liberated trichinæ find their way into the small intestine (*intestinal trichinæ*), where they rapidly grow to the length of about $\frac{3}{8}$ inch. They next bore their way through the intestinal walls and enter the lymphatic vessels (see Part I., p. 8). Here they produce a large number of living young, and shortly afterwards die. The minute young worms are now

Digitized by Google

carried by the lymphatic fluid into the blood-stream, and thence into the muscles (*muscular trichinæ*). Here they remain, living for some time upon the constituents of the muscle, which they destroy, grow rapidly in size, and after rolling themselves up spirally are finally enclosed in a lemon-shaped capsule or cyst. In this condition they may remain for a considerable time without dying. If, however, they are consumed with the flesh of their hosts by man or one of the animals mentioned—and this may not happen till years afterwards—they develop to the perfect sexually mature parasite.



TRICHINA.

I. Intestinal form (× about 50 times). J., Young trichinæ escaping from the body. II. Encysted trichinæ, muscular form (× about 100 times).

In man trichinæ produce a violent, sometimes even fatal, disease known as *trichinosis*. As a protection against it, pork should never be eaten until it has been pronounced free from trichinæ after a microscopic examination, and only then after having been previously *thoroughly boiled, roasted,* or *smoked, for it is by the pig alone that this dreaded parasite is conveyed to man.*

It appears that the true host of the trichina is the rat, which occasionally kills weaker members of its own species and eats them, or feeds on the corpses of its fellows, and thus constantly reinfects itself, *i.e.*, introduces the parasite into its body. From the rat it is conveyed to the pig, in the event of the latter devouring the dead body of an infected rodent. Hence these troublesome and dangerous vermin should be carefully kept away from pig-sties.

Other Thread-worms.

The **Common Round Worm** (*Ascaris lumbricoides*) is a parasite which inhabits the intestine of man, especially children. The female may reach a length of nearly 16 inches.

Another smaller worm, about $\frac{1}{2}$ inch in length, occurs in the rectum in children, sometimes in great numbers (*Oxyuris vermicularis*).

Digitized by Google

The disease of the ears of wheat known among farmers as the "purples" or "ear cockle" is due to a nematode parasite, the **Wheat-Eel** (*Tylenchus scandens*), whilst another, the **Thread-Worm of the Turnip Disease** (*Heterodera schachti*) has frequently caused great damage among turnips.

CLASS III.: FLAT-WORMS (PLATHELMINTHES).

Body flattened, not divided into rings.

ORDER I.: TAPE-WORMS (CESTODES).

The Human Tape-Worm (*Tænia solium*).

A. Egg and Embryo, or Proscolex.

The tape-worm, here to be considered, inhabits in its mature condition the small intestine of man (name). Its eggs, which are of microscopic minuteness, are discharged with the fæces (see Section C, 6). In the interior of each egg is found already the rudiment of the future tape-worm, viz., the embryo, or *proscolex*. It is surrounded by a thick resistant capsule, and therefore not easily affected by moisture, heat, and cold. In order that it may give rise to a tape-worm, it must find its way into the stomach of a pig. Of this there is every probability, for this unclean animal is fond of burrowing among all kinds of filth, into which eggs of tape-worms likewise easily find their way. In the stomach of the pig, the capsule surrounding the proscolex is dissolved by the acid gastric juices, and the latter set free. It works its way into the intestine, the walls of which it pierces with its three pairs of movable hooks. Thence it enters the circulation, and fixes itself within a muscle or other organ. The hooks, being no longer required, disappear, and the proscolex develops into a bladder-like vesicle, varying from the size of a pea to that of a bean. In this condition it is known as—

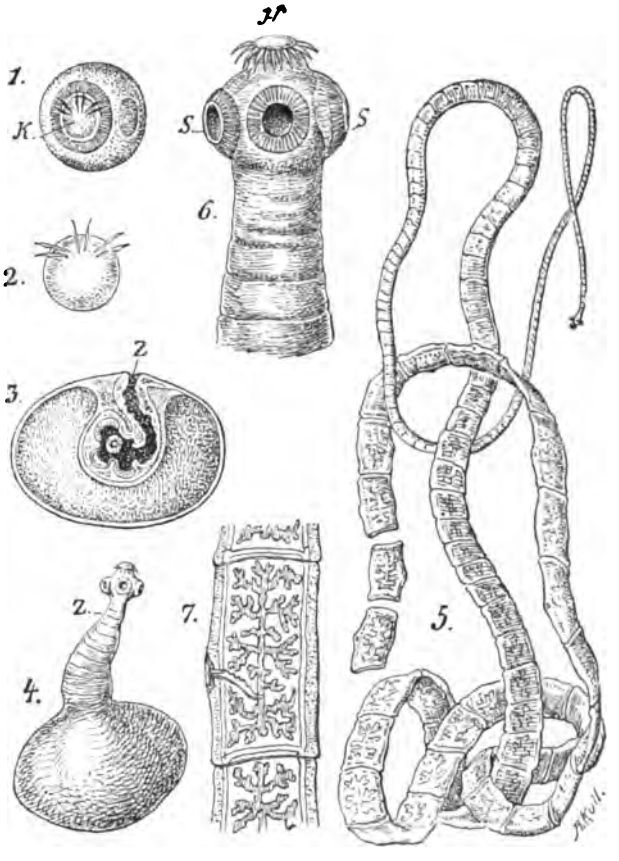
B. Cystic Worm, Cysticercus, or Scolex.

From the wall of the vesicle projects into its cavity a hollow knob, or invagination, at the bottom of which a wreath of small *hooks* and four minute *suckers* (see cuttle-fish) may be distinguished even under a small magnifying power (see Section C, 1). If the pig dies and is buried, the scolices also perish. If, on the other hand, it is killed, and the flesh eaten in an uncooked state by man, the scolices undergo their further development to—

Digitized by Google

C. The Adult Tape-Worm.

1. In the human stomach the vesicle is digested, but the hollow knob is not attacked by the acid gastric juices. On the contrary, it turns inside out, like the finger of a glove, so that the hooks and suckers above



"ARMED" TAPE-WORM OF MAN.

1, Egg, with embryo (proscolex), K., which at 2 has been liberated (× 500 times); 3 and 4, cysticerci—at 3 in section to show the invaginated hollow knob (Z.), which at 4 has been turned out (× 5 times); 5, adult tape-worm—the two last "ripe" segments (proglottides) have been separated from the rest: the actual tape-worm has a much larger number of segments (somewhat less than natural size); 6, head with wreath of hooklets (H.) and suckers (S.); these structures are also seen in Figs. 3 to 5 (× 25 times); 7, a ripe "proglottis" and portions of two others—the dark markings are the ramified ovaries (× 2½ times).

referred to come to lie on the outside. It now migrates to the small intestine, and there attaches, or, as it were, anchors, itself by means of

Digitized by Google

its hooklets and suckers, the importance of which will now be evident. (Why is this attachment necessary?)

2. A short distance in front of the posterior end of the knob, which is now described as the "head" of the tape-worm, an annular groove is soon after formed, a *segment* being thus formed, which, however, remains in connection with the head. Shortly after a second segment is thus constricted off, then a third, and so on, all of which segments grow rapidly in size. In this manner is formed gradually a tape-like (name) chain of segments from 7 to 10 feet long, which, together with the head from which it has been produced, forms the tape-worm. Lastly, the terminal segment, or *proglottis* (*i.e.*, the oldest of all the proglottides), separates off from the chain, and is expelled with the fæces. The same fate befalls the new terminal proglottis (*i.e.*, the second oldest), and so on; and in proportion as segments are lost at the end of the tape-worm, new ones (to the number of a thousand or more) are constantly formed at the head, which, by absorbing food, continues to grow.

3. The tape-worm lives on the nutritive fluid prepared in the stomach and intestine of its "host." (Explain this term.) It thus obtains its food in a digested condition, and hence does not need an *intestinal canal*. For the same reason the beginning and end of such a canal, *i.e.*, a mouth and anus, are also absent. The absorption of food, in which, as it were, the animal swims, proceeds, accordingly, over the whole surface of the body.

4. Hence this *delicate animal* always obtains the moisture which is necessary to its existence (see earth-worm, Section 1).

5. The tape-worm, like most animal parasites which live in the interior of other animals or in plants, is devoid of *eyes* and *colourless*. (Give other examples.)

6. The so-called "ripe proglottides" which have been separated and expelled continue to live for some time after their discharge, but finally perish. Their contained *eggs*—each proglottis has been calculated to contain about 5,000—are set free, and we have accordingly arrived back at the point we started from, having thus completed the life-circle in which the development of the tape-worm proceeds. Whether one of these tough and resistant eggs (see Section A) is consumed by a pig, which may be described as the "intermediate host" of the tape-worm (explain this name), and whether the cysticercus, which may possibly proceed therefrom, eventually arrives in the stomach of a man, are questions of circumstance and accident. Among the *enormous number* of eggs, amounting to many millions, produced by a tape-worm during its lifetime, it is, however, quite probable that this will happen to some. Thus we understand the large number of the eggs, which is only rendered

Digitized by Google

possible by the abundant food-supply of the parasite and the ease with which this is obtained. Further, we also see how the disadvantages of a parasitic mode of life (uncertainty as to the fate of the eggs) is balanced by its advantages (a rich supply of nourishment, and consequently a large number of eggs).

D. The Tape-Worm in its Relations to Man.

Though the tape-worm is far less dangerous to man than the trichina, it nevertheless gives rise to all kinds of digestive disturbances, and is, at any rate, a troublesome messmate, whom it is well to get rid of as quickly as possible. It may, on the other hand, become extremely dangerous when its eggs by some accident or other happen to get into the human stomach, since in this case the proscolex develops into the cysticercus in the body (especially in the brain and eyes). Hence no one should ever eat raw or insufficiently boiled or roasted meat, should practise the greatest cleanliness, and be specially careful of keeping human excreta away from himself and from pigs.

Other Species of Tape-Worm.

By the same means we shall also protect ourselves from other species of tape-worm, two of which especially are frequently found in man—viz., the **Unarmed** or **Beef Tape-Worm** (*Tænia saginata*), the cysticercus of which is found in the ox and other horned cattle (called "unarmed" owing to absence of hooks); and the **Broad** or **Russian Tape-Worm** (*Bothriocephalus latus*), the intermediate hosts of which are the pike and the burbot. Hence the latter is found specially frequently in (European) countries where much fish is eaten (name some). It attaches itself to the intestine of its host only by the help of two elongated suckers.

Our most faithful companion, the dog, houses two extremely dangerous species of tape-worm. The cysticercus ("blister") of the first, the **Blister Tape-Worm**, lives in the brain (especially) of sheep, in which animal it gives rise to the disease known as "staggers." In order to stamp out this disease from the herd, or to prevent it from spreading, it is, of course, necessary carefully to destroy the brains of animals which have died from it. The other species of dog tape-worm, *Tænia echinococcus*, is also a very dangerous guest. It is only from ¼ to ⅜ inch long, and consists of only three or four proglottides. The cysticercus, on the other hand, which lives in the most widely different organs of domestic animals and man, may sometimes reach the size of a man's head. Upon its wall, which is very thick, are formed what are known

Digitized by Google

as "brood capsules," from which numerous "heads," or secondary scolices, are budded out, so that hundreds of these parasites may be produced from a single egg. From its size alone we may judge how dangerous to life such a parasite must be. Therefore, *Beware of the dog! Especially never allow it to lick your face or hands.*

ORDER II.: TREMATODE WORMS, OR FLUKES (TREMATODA).

The trematode worms are flat-worms, which live parasitically on or in other animals. Unlike tape-worms, they possess an unsegmented, generally leaf-like body. They are provided with one or several suckers, by which they adhere to the body of their host. The intestine is bifurcated, and there is no anus, its function being performed by the mouth.

Of the numerous species contained in this order, we shall only mention one, the **Liver Fluke** (*Fasciola hepatica*). This parasite is only about an inch long, and inhabits mostly the bile-ducts of the liver (name), especially of sheep, in which animal it causes the disease known as "rot," by which whole flocks are often exterminated. The parasite passes through a very complicated development (the larva bores its way into a small water-snail, and multiplies by repeated division in the interior of the host), and is probably swallowed, while encysted upon wet grass, by sheep on their pastures.

Digitized by Google

DIVISION OR TYPE V.: SPINY-SKINNED ANIMALS (ECHINODERMATA).

Radially symmetrical, usually five-rayed animals, with the integument hardened by calcareous deposits, usually raised above the surface in the form of spines, and provided with a water-vascular system, which is continued into the organs of locomotion (sucking-feet). Of marine habitat.

CLASS I.: STAR-FISHES (ASTEROIDEA).

The Common Star-Fish (*Asterias rubens*).

(Diameter usually from 4 to 6 inches.)

A. Distribution.

The star-fish is common on all European coasts excepting those of the Mediterranean. (See illustration, p. 462.) People living inland regard this animal with special interest—not only on account of its variable

B. Colour,

red, yellow, brown, to almost black, but principally on account of its utterly unusual

C. Shape,

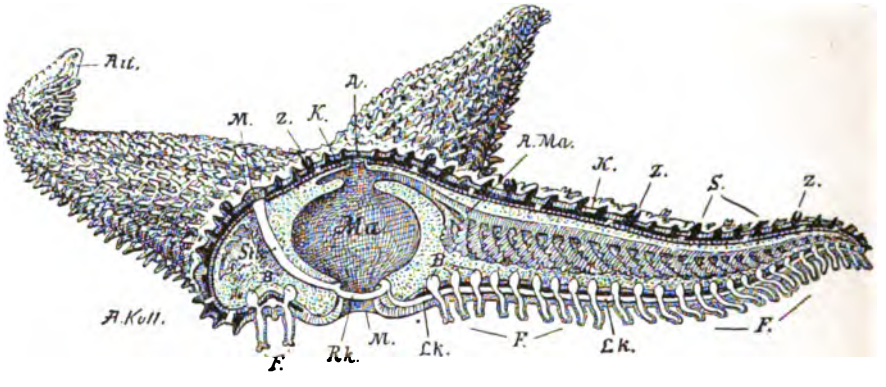
which is that of a five-rayed star (name). The lobes which radiate from the central, disc-shaped body are called "rays" or "arms." All the animals hitherto considered were bilaterally symmetrical; *i.e.*, their body was divisible by *one* section into two similar halves, and in them we were able to distinguish a right and left side and a front and back. The body of a star-fish, on the other hand, consists of five similar parts; for if we draw imaginary lines from the centre of the disc to the angles between the radii, we obtain five such similar segments. (The number five is very frequently repeated among the echinoderms, as we shall see

Digitized by Google

later on.) Hence, the star-fish (like all echinoderms and cœlenterates) is constructed on a *radiate* or *radially-symmetrical* type, in which upper and lower surfaces are different, but bilateral symmetry is very slightly indicated.

D. Body Covering.

In the soft *integument* are deposited numerous *calcareous plates*, which afford an important and necessary protection to this slow and defenceless creature. In spite of this armour, however, both the body and arms are very movable, owing to the calcareous plates moving easily upon each other. After death, however, they render the body rigid. (Compare with arthropods, p. 308.)



SECTION THROUGH THE DISC AND ONE OF THE ARMS OF A STAR-FISH (DIAGRAMMATIC).

K., Calcareous integumentary plates (shown black), elevated into numerous spines (S.) and several pincers (pedicellariæ) (Z.); M., madreporic plate; Stk., stone canal; Rk., circular canal; Lk., longitudinal canal. On the left the latter, which extends along the bottom of the left arm, is shown in transverse section as a white circular spot. From it the lateral canals (not visible on the right) pass off to the ampullæ (B.) and the pedicels (F.). M., mouth shown widely opened; Ma., stomach; A.Ma., a branch or cæcal pouch of the stomach extending into the right arm; on the left of the stone canal the stomachal pouch is shown in transverse section.

On the outside these plates are produced into numerous *spines*, which likewise protect the animal from attack. Among these structures are also found numerous minute *pincer-like* bodies (pedicellariæ), borne upon movable stalks, the function of which is not yet definitely ascertained. The majority of naturalists are inclined to regard them as organs for cleansing the skin, for both star-fishes and sea-urchins are always remarkably clean and white, in spite of the fact that their spiny coat is well adapted for harbouring all kinds of plants and minute animals—indeed, far more so than the shell of crustaceans (see p. 422), which we frequently find almost overgrown with foreign bodies.

Digitized by Google

E. Organs of Locomotion.

If we watch a star-fish in the act of creeping, we notice a number of white threads protruding under the arms, making it appear as if worms were crawling out of its interior. These are processes of the integument, the so-called sucking-feet, or pedicels, of which the animal possesses hundreds, as a glance at its under side at once reveals. They are placed close to each other in two double rows, along grooves extending from the mouth (also placed on the ventral surface), to the tips of the arms. While in repose they appear like small cutaneous papillæ; but when the animal wishes to move they all extend in length, and turn towards the side in which motion is to take place. They next attach themselves to the supporting surface by their free ends, each of which forms a small sucker (see suckers of cuttle-fish), after which they contract, so that the body is drawn forwards by as many ropes, as it were. Finally they once more become detached from the surface of support, and the performance is repeated. By the help of these suckers the star-fish is even able to climb up perpendicular walls (*e.g.*, the glass sides of the aquarium), and they also assist the animal in the consumption of its prey (see Section G). These peculiar pedicels are in their turn set in action by means of a

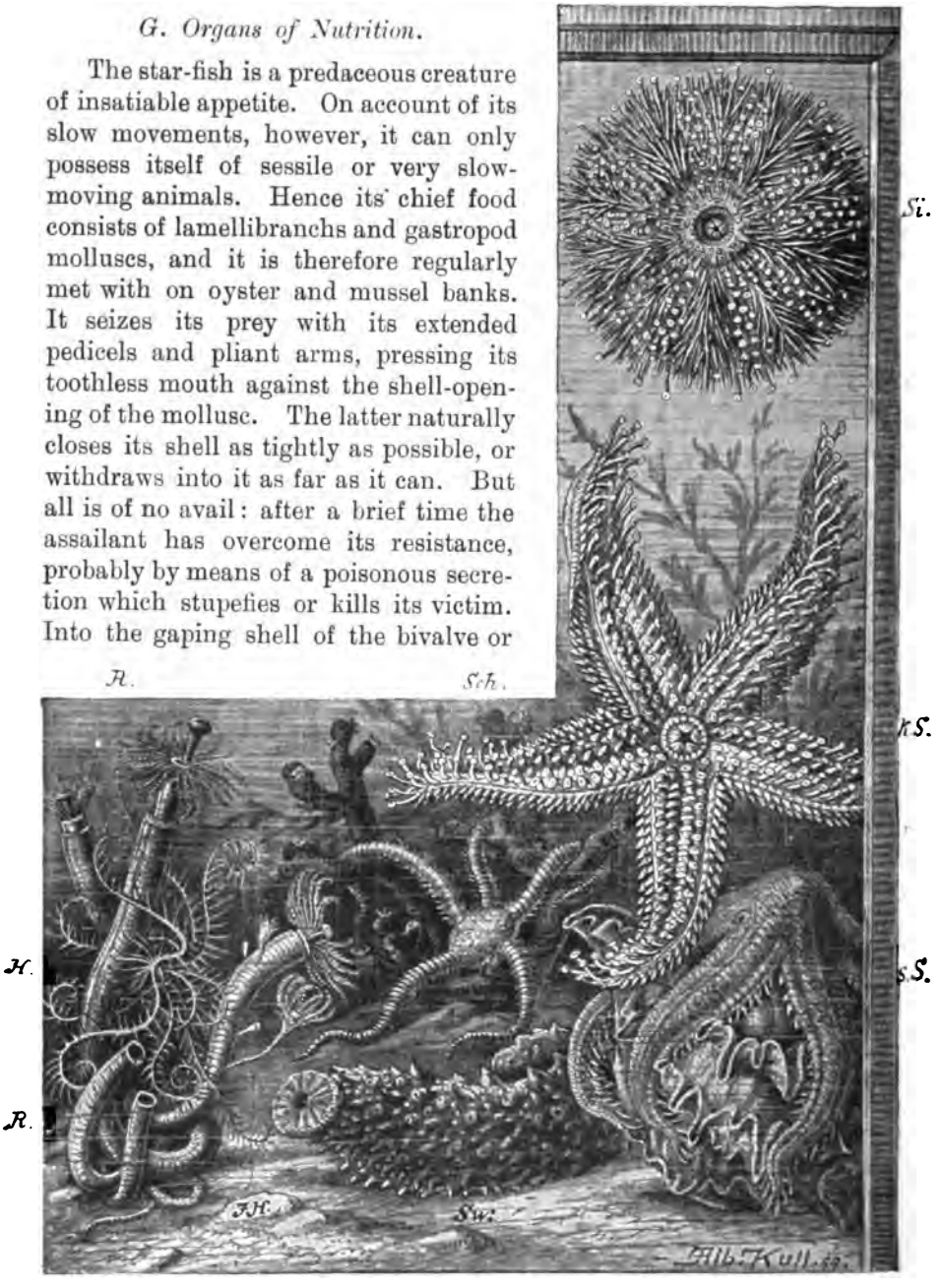
F. Water-vascular System,

such as we do not find repeated throughout the whole realm of Nature. On the upper surface of the disc, near its centre, is seen a small calcareous plate, perforated like a sieve, and known as the *madreporic plate*, through which sea-water enters from without into the body of the animal. It is connected by a small canal called the *stone canal*, because its walls are calcified, to another canal, which forms a ring around the stomach near the mouth, and is hence called the *circular canal*. From the latter a branch, the *longitudinal canal*, extends along each arm to its tip, from which, again, *lateral canals* pass off like barbs from the shaft of a feather. Each of these small lateral branches dilates inwardly into a small vesicle (*ampulla*), while outwardly it is continued into the cavity of the tubular *pedicels*, with which we have already become acquainted. When the muscles in the walls of these ampullæ contract, water is pumped into the tubular pedicels, which are consequently stretched in length like a worm. On the other hand, if the muscles in the walls of the foot contract, causing it to shorten, the water returns to the corresponding ampulla. Thus, the star-fish can force water into all or many or only a few of its pedicels, according to what is required for the performance of any particular task.

Digitized by Google

G. Organs of Nutrition.

The star-fish is a predaceous creature of insatiable appetite. On account of its slow movements, however, it can only possess itself of sessile or very slow-moving animals. Hence its chief food consists of lamellibranchs and gastropod molluscs, and it is therefore regularly met with on oyster and mussel banks. It seizes its prey with its extended pedicels and pliant arms, pressing its toothless mouth against the shell-opening of the mollusc. The latter naturally closes its shell as tightly as possible, or withdraws into it as far as it can. But all is of no avail: after a brief time the assailant has overcome its resistance, probably by means of a poisonous secretion which stupefies or kills its victim. Into the gaping shell of the bivalve or



ECHINODERMS (AND TUBICOLOUS ANNELIDS) IN THE AQUARIUM.

K.S., *Common Star-Fish* creeping up glass side of aquarium; s.S., the same species embracing and sucking out a gastropod mollusc; Si., *Common Sea-Urchin* adhering to glass side; Sw., a *Sea-Cucumber* (*Holothuria tubulosa*); Sch., a *Sand-Star* (ophiurid); R., several *Tubicolous Worms*—three with their branchiæ extended above the aperture of the tube; upon the middle one a *Feather-Star* (H.) has become firmly entwined, while on the right are shown *four larval stages of the Feather-Star* (J.H.), of which the two larger ones are slightly magnified.

Digitized by Google

that of the gastropod the star-fish now lowers its sac-like stomach, which is turned inside out through the mouth, the food being digested outside of the body. Small molluscs are also taken into the stomach whole, the empty shells being rejected after the completion of the meal. A *branch* or *cæcal pouch* extends from the stomach into each arm, where it again divides into two branches. The *anus* lies on the centre of the upper surface.

H. Organs of Sense.

The suctorial feet, or pedicels, form very sensitive *tactile organs*, while at the tips of the arms are found small red spots which naturalists regard as *organs of sight*.

I. Reproduction.

Reproduction is effected by means of *eggs*. The larvæ to which they give origin pass through a very complicated metamorphosis before they assume the parent shape.

OTHER ECHINODERMS.

CLASS II.: THE BRITTLE STARS AND SAND STARS (OPHIUROIDEA).

EXTERNALLY these bear a close resemblance to the star-fishes. Their arms, however, are sharply separated from the disc, and are long, thin, and of snake-like flexibility (hence name; Ophiura = snake-tail). In some species, hence known as "Medusa-heads" (explain the name), they are branched like trees, or arborescent.

CLASS III.: THE FEATHER STARS OR SEA-LILIES (CRINOIDEA).

THIS is a group of echinoderms which is almost extinct (fossil crinoids); only scanty remnants have survived to our time, and most of these live in the deepest, most inaccessible abysses of the ocean. Their small cup-shaped body is supported upon a fixed jointed stalk, and is furnished with a crown of much-branched arms (feather stars), so that these delicate, often richly-coloured creatures are more like a flower than an animal (sea-lily). Along the coast are found species—*e.g.*, the **Mediterranean Feather Star** (*Antedon rosacea*), which is of the most beautiful colours—which are sessile only during the early stages of their life, but later on sever their connection with the stalk, and by means of

Digitized by Google

tendril-like climbing feet (cirri) creep about on seaweeds, etc. Their microscopic food (see p. 438, Section d) is swept by means of cilia, which cover the floor of the brachial grooves, towards the mouth, which is directed upwards.

CLASS IV.: SEA-URCHINS (ECHNOIDEA).

With this division, which is rich in varied forms, we shall make ourselves acquainted by briefly considering one species, viz., the **Common Sea-Urchin** (*Echinus esculentus*). This animal lives in the seas of Northern Europe, and has but little resemblance to the star-fishes. By imagining, however, the arms of a star-fish curved over its back in such a manner that their margins touch each other, and, further, the calcareous plates fused into a solid shell, or "test," we arrive at the apple-shaped body of the sea-urchin, with the mouth below, the anus above, and between the two, five rows of pedicels. The shell, or "test," bristles all over with sharp movable spines, which point in all directions, and serve both as excellent weapons of defence (compare with hedgehog; name) and also as stilts, on which the animal strides along. The principal organs of locomotion, however, are the pedicels. By their aid the sea-urchin is even able to climb with dexterity and to ascend those marine plants which form its special food. For cutting off and dividing its food the animal is provided with five sharp teeth, which project slightly from the oral opening, and the muscles of which are attached to a framework of calcareous triangular pieces (alveoli).

CLASS V.: SEA-CUCUMBERS (HOLOTHUROIDEA).

Imagine a sea-urchin much drawn out longitudinally, so that a roller-shaped body is formed, with the mouth at one end and the anus at the other, and we have an animal of the shape displayed by the sea-cucumbers. The skin in these animals, however, is leathery, and contains only small isolated calcareous bodies, whilst the mouth is surrounded by a crown of, frequently branched, tentacles. Several species found on the coasts of the East Indian and Australian seas are in large quantities prepared into trepang, which is a favourite delicacy in China.

Digitized by Google

DIVISION OR TYPE VI.: CŒLENTERATA.

RADIALLY symmetrical, four or six rayed animals possessed of a single internal cavity, which represents the body cavity, alimentary canal, and blood-vascular system of higher animals.

Before considering the separate divisions of the Cœlenterata, we shall examine, by way of an introduction to the structure of this wide-branching division of the animal kingdom, a species easily understood and accessible, viz.:

The Fresh-Water Polyp (*Hydra*).

A. Occurrence and Mode of Capture.

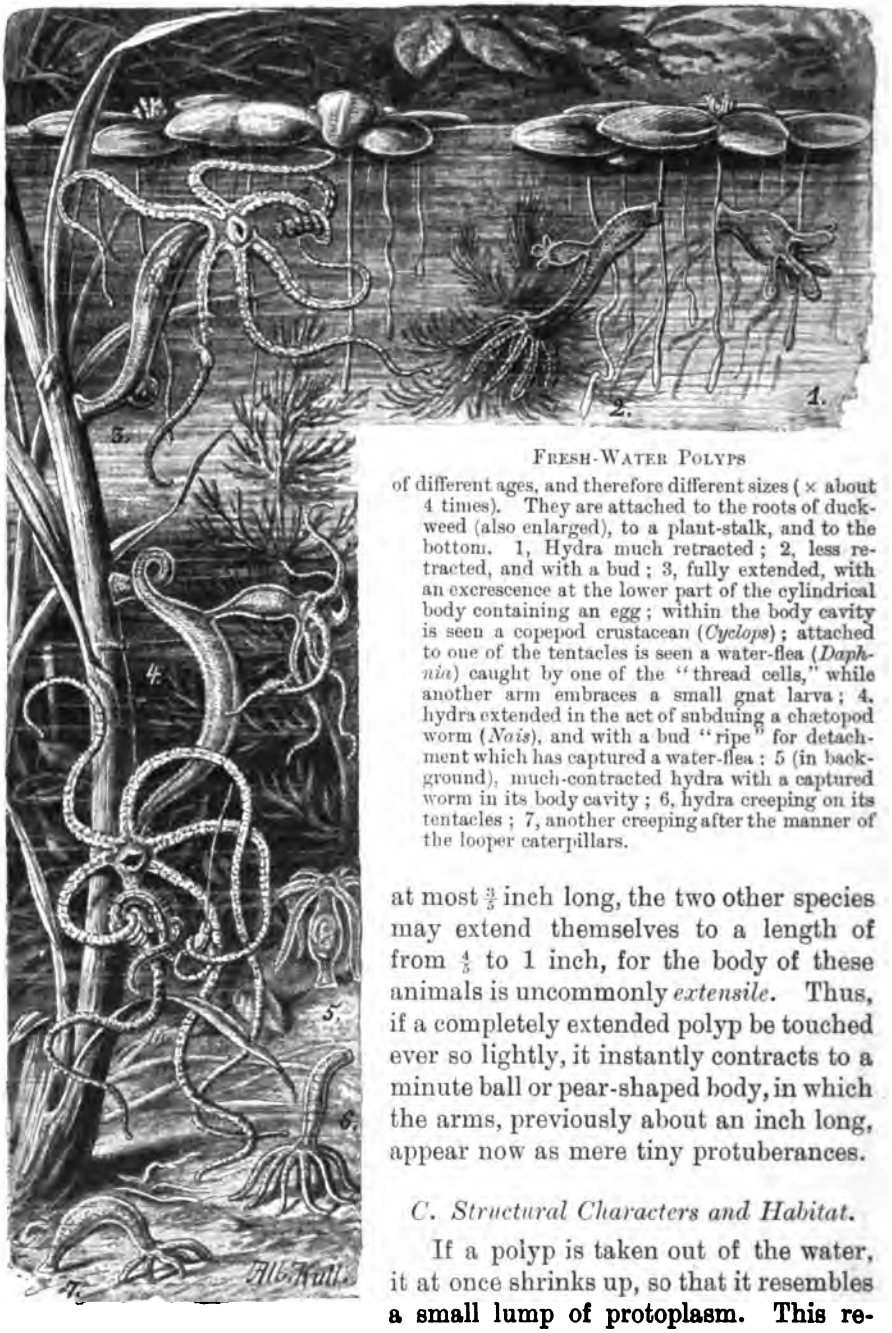
If from a fresh-water pond or stream (name) we take a little water with some duckweed or other water-weeds, and allow them to stand in a glass for some hours, we shall, if we are fortunate, easily discover fresh-water polyps.

B. Appearance and Species.

They will be found attached to the side of the glass or other object by one end of their cylindrical body, while at the other end from six to twelve very fine hair-like threads, the so-called *tentacles*, play freely about in the water. These polyps vary considerably in *colour*. Most frequently they are brownish, less commonly green, and still more rarely of grey or reddish colour. These differently-coloured examples, however, display also regular differences in their finer structure (these do not interest us here), and are therefore described as three distinct species, named, according to their predominant tint, respectively the **Brown, Green,*** and **Grey Fresh-Water Polyps** (*H. fusca, viridis*, and *grisea*). These different forms also vary in size, for whilst the green hydra is

* The green hydra derives its colour from unicellular algæ (*Zoochlorella*) embedded in its tissue. These live upon the carbonic acid gas expired by the animal, to which on their part they give up in exchange oxygen and probably food materials which they have elaborated. We have here a case of combination for mutual benefit (symbiosis), between an animal and a plant, which is repeated in several other (green-coloured) animals.

Digitized by Google



FRESH-WATER POLYPS

of different ages, and therefore different sizes (× about 4 times). They are attached to the roots of duck-weed (also enlarged), to a plant-stalk, and to the bottom. 1, Hydra much retracted; 2, less retracted, and with a bud; 3, fully extended, with an excrescence at the lower part of the cylindrical body containing an egg; within the body cavity is seen a copepod crustacean (*Cyclops*); attached to one of the tentacles is seen a water-flea (*Daphnia*) caught by one of the "thread cells," while another arm embraces a small gnat larva; 4, hydra extended in the act of subduing a chætopod worm (*Nais*), and with a bud "ripe" for detachment which has captured a water-flea: 5 (in background), much-contracted hydra with a captured worm in its body cavity; 6, hydra creeping on its tentacles; 7, another creeping after the manner of the looper caterpillars.

at most $\frac{3}{5}$ inch long, the two other species may extend themselves to a length of from $\frac{4}{5}$ to 1 inch, for the body of these animals is uncommonly *extensile*. Thus, if a completely extended polyp be touched ever so lightly, it instantly contracts to a minute ball or pear-shaped body, in which the arms, previously about an inch long, appear now as mere tiny protuberances.

C. Structural Characters and Habitat.

If a polyp is taken out of the water, it at once shrinks up, so that it resembles a small lump of protoplasm. This re-

Digitized by Google

markable change of shape will be understood if we place the animal in a watch-glass with some water, and, after it has become again extended, examine it under the microscope. The most careful examination will reveal no trace of any supporting or protective structure (compare, *e.g.*, with mammals and insects). Hence, such a polyp could only live in *water*, which carries it and supports it on all sides. Here, too, it finds the protection against evaporation which it requires on account of its soft and completely unprotected body (see Part II., p. 253).

D. Structure and Food.

By bringing into the vessel containing the polyps a number of minute crustaceans, such as are found in every pool, we shall be able to observe the manner in which our captives feed. If one of the crustaceans happens to come in contact with the tentacle of one of the polyps, it is suddenly arrested in its swimming movement, and remains fixed to the spot as if spellbound. If the polyp is hungry it contracts its tentacle; the other tentacles assist in grasping the prey, and it is soon conveyed into the interior of the cylindrical body.

(*a*) Since the polyp lives exclusively upon small crustaceans and other minute aquatic creatures, it requires prehensile organs such as these arms or tentacles. (Contrast with aquatic animals which sweep the food into their mouths—*e.g.*, lamellibranchs.)

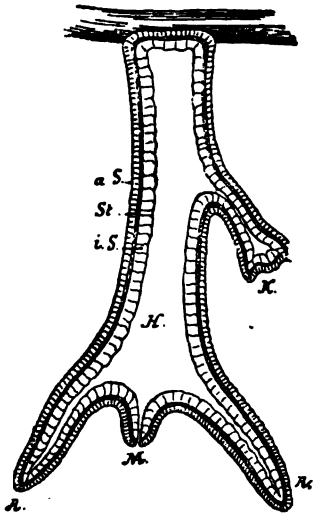
"THREAD CELLS" OF FRESH-WATER POLYPS. (Very strongly magnified; somewhat diagrammatic, and in section.)

I., In quiescent condition (with the stinging-thread rolled up spirally in the capsule). II., In the active everted condition (the stinging-thread ejected).

(*b*) Why, however, does the crustacean remain fixed, as though spellbound, to the tentacles? If a living fresh-water polyp be placed under the microscope, and covered with a thin cover-glass, we shall see, even under a small magnifying power, a large number of clear vesicles embedded in the outer cellular layer, or ectoderm, of the tentacles and body (see Section D, *d*). If a drop of acetic acid be now admitted under the cover-glass, fine threads will be seen to be ejected from the capsules, in which they previously lay spirally coiled up. Owing to the action of the acid, the cells explode, as it were, and hurl forth the threads like stings, the thread, by a process of evagination, being turned inside out, like the finger of a glove. These threads are often provided with recurved spines near

Digitized by Google

their bases. Now, exactly the same thing happens when one of the small crustaceans above mentioned touches the tentacle. Forthwith it is hit by a larger number of these missiles, which, being hollow and conveying a poison from the capsule into the body of the victim, apparently kill or paralyze the latter, which is thus bound helpless to the arm of its assailant. The human skin is too thick to feel the effect of these weapons, though many species allied to the fresh-water polyps can inflict in some cases very painful stings by means of exactly similar organs. In the case of some species the sensation is like being burnt with a red-hot iron, in others like putting one's hand among stinging-nettles. From the stinging action of these organs they have been called *thread or nettle cells* (cnidæ, or nematocysts), and the animals provided with these organs —*Cnidaria* or *Nematophora* (Greek *cnidē*, a nettle; *nema*, a thread; and *phoreo*, I bear —*i.e.*, nettle- or thread-bearing animals).



LONGITUDINAL SECTION THROUGH A FRESH-WATER POLYP (DIAGRAMMATIC).

The animal (in order to facilitate comparison with a jelly-fish) is shown attached to a plant-stalk, with its mouth pointing downwards. A., Two tenacles; H., body cavity; M., mouth; a.S., external layer of integument (ectoderm); i.S., internal layer (endoderm); St., supporting layer (mesoderm); K., bud.

(*c*) The opening through which we saw the crustacean disappearing into the interior of the polyp is the *mouth*, which, however, in the absence of a second body aperture, also serves as *anus*.

(*d*) A longitudinal section through the polyp (see illustration) clearly shows that the mouth leads into a spacious *cavity*, which is continued also into the tentacles. This space corresponds to the body cavity of higher animals in which the viscera are lodged; secondly, it carries out digestive functions performed in the latter by the intestinal canal, and finally conveys the digested nutriment to all parts of the body, which function in the higher animals is carried out by the bloodvessels. Thus, the structure of a polyp is a very simple one, and since all its allies also possess such a *single* body cavity, they are described as *Cœlenterata*, *i.e.*, *hollow animals* (Greek *cœlos*, hollow, and *enteron*, the bowel). The walls lining this body cavity are composed of two layers (ectoderm and endoderm), composed of those minute bodies which have been already referred to as cells (Part II., p. 253). Interposed between these two layers is a third very thin layer not composed of cells, and somewhat

Digitized by Google

firmer than the other layers. This is accordingly described as the *supporting layer* (mesoderm). If we imagine a longitudinal axis drawn through the centre of the body cavity, all the body parts will be arranged symmetrically around this axis. The polyp, therefore, with all other Cœlenterata, displays a *radiate* or *radially symmetrical type of structure*, like the echinoderms (see p. 459).

E. Reproduction.

(*a*) If the polyps are supplied with an abundance of food, it will be seen after a few days that a small excrescence is developed on the body of one or other of the animals, and into this the body cavity is continued. It grows rapidly in length; a mouth and tentacles are developed at its free end; finally, it separates from the body of the old polyp, and thus gives rise to a young animal. This process reminds one of the budding of plants, and is therefore described as *budding* or *gemmation*, the excrescence itself being termed a *bud*.

(*b*) If, on the other hand, the polyps are allowed to go without food for a considerable time, or if the water in which they live dries up, or the weather gets too cold (in spring, autumn, or winter), small excrescences are again formed on the body, each of which this time contains an *egg*. When ripe this delicate egg drops off, but, being surrounded by a strong chitinous envelope (see p. 308), it can be attacked neither by frost nor drought. This is of the highest importance to an animal which would be killed by the cold of winter or by the drying up of the water in which it lives. At the same time, the production of eggs of such minute size, which can be easily wafted away by the wind, is an excellent means for *disseminating the species*. We can now also understand why these eggs are produced *exactly at the time when food is scarce, the weather cold, and waters liable to dry up*.

CLASS I.: JELLY-FISHES AND HYDROIDS (HYDROZOA).

The polyps in this division have no œsophageal tubes, and the body cavity is not subdivided by mesenteries. (See Anthozoa, p. 473.)

ORDER I.: LOBED MEDUSÆ (ACALEPHÆ).

The Common Jelly-Fish (*Aurelia aurita*).

(Diameter of disc up to 6 inches.)

A. Occurrence.

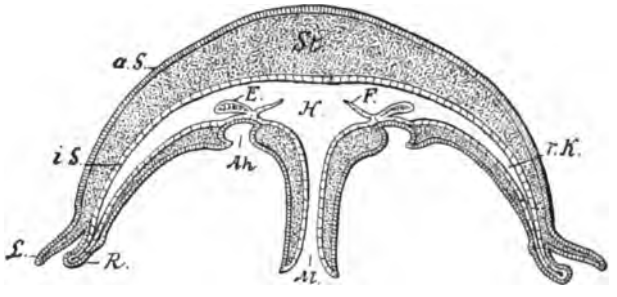
Anyone who has seen the sea must have noticed the peculiar jelly-fish among the varied inhabitants of its teeming waters. Among these

Digitized by Google

the species selected for description is of common occurrence on the European coasts, where in late summer and autumn it frequently makes its appearance in countless numbers.

B. Constitution of Body and Colour.

When thrown on shore by a boisterous wave, the soft body of one of these animals, which is saturated with water, soon disappears. The open sea is indeed the element of these delicate, transparent creatures (see fresh-water polyp). In its waters they swim about gracefully, exhibiting light blue and red tints, and, to all appearance, in perfect peace. Anyone, however, who has ever encountered them while bathing



LONGITUDINAL SECTION THROUGH AN ACRASPEDOTE MEDUSA (DIAGRAMMATIC).

a.S., External and, i.S., internal cutaneous layers (ectoderm and endoderm); St., supporting or jelly layer (mesoderm); M., mouth; H., body cavity; r.K., radial canal, running to edge of umbrella; E., ovary; F., gastric filament, projecting into the body cavities; Ah., recesses (genital chambers) on lower surface of umbrella; L., a lobe of the umbrella, covering R., a marginal sense body, or tentaculocyst.

knows that they do not bear a bad reputation entirely without reason, though their stinging powers are but slight.

C. Structure.

Though the jelly-fish has externally only a slight resemblance to the fresh-water polyp, a closer inspection reveals a complete similarity in their plan of structure. This is at once shown by a comparison of the appended illustration with that shown on p. 468. Let us imagine the body of a fresh-water polyp flattened out into a *disc*, and the supporting layer in the lower part of the body thickened into a broad *gelatinous or jelly layer*; let us further imagine the lower surface of the disc recurved inwardly, so that its central portion hangs downwards like the handle of an umbrella; and finally let us picture to ourselves this handle, at the end of which the *mouth* is placed, drawn out into four fringed lobes or processes, and we shall have a fair representation of our jelly-fish. To

Digitized by Google

complete the picture we need only add a few further details. The mouth (as in the fresh-water polyps) leads into the digestive or body *cavity*, from which numerous *canals* pass out *radially* towards the edge of the umbrella. As it leads a free and active life, the jelly-fish is provided at the *lobed* edge of its umbrella with numerous *feeler-like* threads or tentacles, as well as a number of small bodies which support the organs of sense (marginal bodies, or tentaculocysts). The latter convey visual and probably also auditory impressions. Living in a free condition, the jelly-fish is also able to move voluntarily from place to place. By the forcible contraction of the edges of the umbrella the water contained under the concavity of the bell is driven out, and the animal, with the convex side of its body turned forwards, swims backwards through the water (like the cuttle-fish).

This general structural agreement of the jelly-fish and fresh-water polyp is, however, by no means accidental, for we may daily still see how the one of these two animals is developed from the other, for which purpose we shall briefly examine—

D. The Development of the Jelly-Fish.

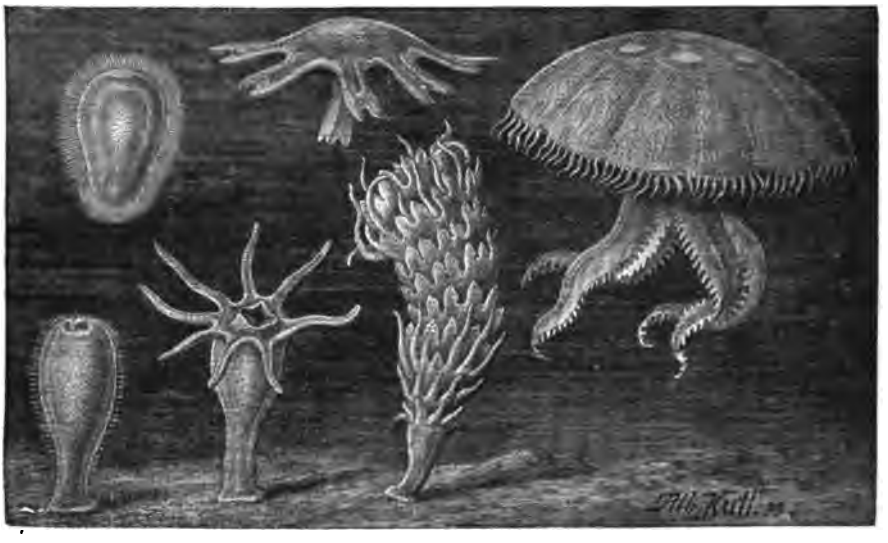
The egg gives rise to an oval-shaped larva (planula), which for some time swims about freely in the sea. It then attaches itself to some fixed object, and assumes the shape of a hydra, or fresh-water polyp (hydra-tuba stage), which, however, by ring-like constrictions is soon separated into a number of discs (strobila stage). The uppermost of these discs finally falls off and becomes a medusa, or jelly-fish, such as we have just described; the second disc follows suit in the same manner, and so on. *Thus, from the egg of the medusa is produced a hydra, or polyp, which by division again produces medusæ.* The animal therefore appears in two perfectly distinct generations, viz., as polyp and as medusa, which alternate with each other, whence this mode of reproduction has been termed *alternation of generations.*

ORDER II.: HYDROID POLYPS (HYDROIDEA).

In the **Fresh-Water Polyp** (*Hydra*) we have already become acquainted with a species of this extensive group which rendered us familiar with the *structure* of Cœlenterata in general, and that of the Hydroidea in particular. With the exception of this species and another, which, starting in brackish water, is gradually encroaching more and more into fresh water, all the others are of marine habitat. They are, however, distinguished from the fresh-water polyps by the fact that all the polyps

Digitized by Google

produced by budding remain in connection with each other. In this manner, by continuous budding, *polyp colonies*, or *polyp stocks*, are formed, which resemble small trees or shrubs, delicate cushions of moss, etc. (hence old name "zoophytes," *i.e.*, plant animals). All the members of a polyp colony are, however, united by a canal, which traverses the stem and branches of the stock, so that the food captured by one of the polypites benefits also all the other "persons" of the colony. Such a colony, with its frequently numerous ramifications, of course requires special supporting apparatus for maintaining its separate parts erect in



DEVELOPMENT OF AURELIA AURITA.

1, Free swimming larva (planula); 2, younger, and 3, older, polyp (or hydratuba) stage, which in 4 is divided into a number of discs (strobila); 5, separated uppermost disc, *i.e.*, a young medusa (*Ephyra*) which develops into the adult form 6 (1 to 5 magnified); 6, a young jelly-fish.

the water. (Compare with colony-building corals and with solitary polyps.) Accordingly, the body surface secretes a chitinous envelope (polypary; see p. 308), in the form of a tube, which encloses the stem and branches of the colony, and usually also the separate polyps. The coloured chitinous covering of a polyp stock (*Sertularia*), which extends over large areas of ground in the shallow waters of the North Sea, has recently been introduced into commerce under the name of *sea-moss*, and is used for artificial flowers.

In every colony we meet with a remarkable *division of labour*. In addition to the animals which are engaged in nutritive functions,

Digitized by Google

and hence possessed of a hydroid shape (nutritive zooids), others are budded forth which are solely restricted to the task of reproducing and spreading the species (generative zooids, or gonophores). These gradually assume more and more the medusoid shape, and, finally separating from the parent stock, swim about freely as true medusæ, or jelly-fish. These minute jelly-fish, however, are distinguished from the Discophora, or acraspedote medusæ, among other points, by the margin of their umbrella never being lobed, but being, on the other hand, provided with a border, or velum, passing inwards from the edge of the umbrella, and thereby narrowing the aperture of the latter (they are hence known as *craspedote, i.e., fringed or veiled, medusæ*). From the eggs of these medusæ are again produced polyp colonies, which in their turn produce the new generation of medusæ by a process of budding, or gemmation. Hence here, too, reproduction takes place by *alternation of generations*.

In several forms the generative zooids, or gonophores, do not separate from the common stock; while, finally, there are species in which the medusæ produce medusæ directly without the interposition of an asexual generation (for example the *Trachomedusæ*). Thus, in the former the medusoid, and in the latter the hydroid, generation is omitted.

CLASS II.: CORALS AND SEA-ANEMONES (ANTHOZOA).

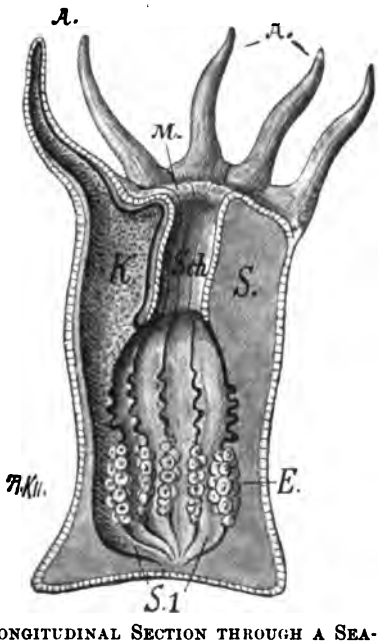
POLYP-SHAPED animals with an œsophageal tube, and with the body cavity divided by vertical partitions, or "mesenteries."

Anyone who has stood in front of a sea-water aquarium in which naked pieces of rock are converted by **Sea-Anemones** (*Actiniaria*) into flower-beds will acknowledge that these animals do not bear their name without reason. These delicate, richly-coloured creatures, with the numerous tentacles surrounding their mouth, indeed resemble animated flowers (Anthozoa = flower animals), and convey some notion of the fairy-like splendour displayed in the "coral gardens" of the Southern seas.

With one species we have already become acquainted as a "commensal" of the hermit crab (see p. 420). Like all the other forms, it resembles a hydroid polyp in external appearance, but is distinguished from it by the fact that the mouth is invaginated into the body cavity as a so-called *œsophageal tube*, whilst the body cavity is divided, after the manner of a poppy capsule, into a number of radiating *compartments* by radial *partitions*, or *mesenteries*. These partitions are given off from the internal body wall, and above are connected with the œsophageal tube,

Digitized by Google

but below the level of the latter project freely into the body cavity, like wings on the stage of a theatre. Each chamber is continued above into a hollow, unbranched tentacle. The number of these tentacles (as in the following group) is usually six or a multiple of this number. When touched, the sea-anemone at once shrinks together to such an extent that the once flower-like creature now resembles an inconspicuous lump (see illustration, p. 421).



LONGITUDINAL SECTION THROUGH A SEA-ANEMONE (DIAGRAMMATIC).

The section has been carried out in such a manner as to expose on the left one of the mesenteric chambers (K.), and on the right a mesentery (S.); in addition to the latter, four others are shown (S.1), which project into the body cavity like the wings on a stage: on the lower part of the mesenteries eggs (E.) have developed; Sch., œsophagus; M., mouth; A., tentacles: into that furthest on the left the body cavity is seen to extend.

In the **Stone Corals** (*Madreporaria*), contrary to what we see in the sea-anemones, the young animals produced by budding (see p. 469) remain connected with the parent stock and with each other. Hence arise colonies such as we have already seen among the Hydrozoa. As in the latter, we here also meet with structures—generally in the form of stony *calcareous secretions*—which supply the colony with its necessary support. Each coral stock, or corallum, takes its origin from a single zoophyte, which attaches itself to some solid object, generally a stone or rock, and develops into a small sea-anemone. On the lower surface of its cylindrical body the animal secretes a calcareous plate (foot-plate), by which it is connected to the surface of support. Next, by further secretion of calcareous material, a number of radiating ridges (costæ) arise from the foot-plate, their outer ends being united by an annular wall (the theca). The "calcareous skeleton" thus developed pushes the body of the polyp in front of it, as it were, whence it often happens that thousands of the living animals are continuing to build upon the branches of the corallum, whilst its lower parts have long since died off. The immense reefs constructed by these minute delicate animals in tropical seas, sometimes forming whole island groups and mountain chains, are of great importance both geographically and geologically.

Digitized by Google

The colonies of the **Precious Red Coral** (*Corallium rubrum*) are constructed on an essentially different plan. They form small tree-like growths, extending to a height of about 12 inches, the stems and branches of which are traversed by a solid calcareous axis, and covered by a soft layer (cœnosarc), as a tree by its bark. (The precious coral, with its nearest allies, forms the group of *alcyonarian* corals.) The zooids are situated in apertures of the red cœnosarc; they possess eight pinnately-fringed tentacles, and resemble snow-white flowers. The animal lives in the Mediterranean, and selects for its habitat by preference the under surface of overhanging rocks. They are caught in large nets fixed to a heavy crossbeam, for the calcareous axis of these animals, which is of marble-like hardness and capable of a high degree of polish, is, as is well known, valued almost as highly as a precious gem, and fabricated into all sorts of ornamental articles.

Digitized by Google

DIVISION OR TYPE VII.: SPONGES (PORIFERA).

ANIMALS of asymmetrical shape, aquatic, with a canal system originating in numerous small pores on the surface, terminating in large oscula.

The Fresh-Water Sponge (*Spongilla*).

A. Occurrence.

Fresh-water sponges (several species of which are distinguished by naturalists) are frequently found in lakes, ponds, rivers, and canals in the form of green (see p. 465, note) or grey masses of various sizes, and attached to stones, piles of bridges, and other objects.

B. Shape.

Their shape shows considerable variation. They sometimes occur in the form of crusts or lumps; sometimes they are branched like trees and antlers. In many cases they are thoroughly asymmetrical in shape. This is surprising, since in their structure animals with few exceptions exhibit great symmetry. Such symmetry is, in fact, a necessary condition for most animals; for a freely-moving animal could no more be of asymmetrical shape than could a locomotive steam-engine (proofs). On the other hand, stationary engines and sessile animals need not be constructed on a symmetrical plan.

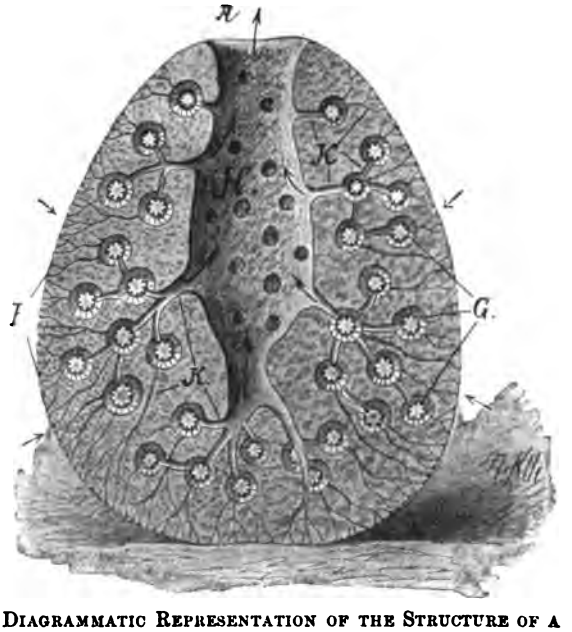
C. Structure.

(*a*) It is difficult to imagine a shapeless lump like a fresh-water sponge to be a *living animal*, and yet such it certainly is. This we can easily prove by placing a sponge which has been detached rapidly in a vessel with water, and repeating our experiment with the pigment granules (see crayfish and fresh-water mussel). If the granules approach too close to the large apertures which we see on the surface of the sponge, they are swept away, which shows that a current of

Digitized by Google

water is proceeding out of the sponge, and that the latter must accordingly be endowed with life.

(*b*) As in lamellibranchs (see p. 437), this current is produced by the constant movements of cilia which are developed on the walls of small cavities, the so-called "flagellated chambers." The water is carried to these chambers by numerous *canals* (afferent canals), which open by numerous small *pores* on the surface of the sponge. Other (efferent) canals conduct the water from the flagellated chambers to a larger channel, from which it is finally expelled by one of the large surface openings above mentioned, which are known as *oscula*.



DIAGRAMMATIC REPRESENTATION OF THE STRUCTURE OF A SPONGE.

P., Pores on surface; K., canals by which the water is carried to the flagellated chambers (G.), and thence to the cavity (H.); A., osculum or exhalant aperture. The arrows denote the direction of the current.

(*c*) As in the lamellibranch mollusca (see p. 438), the respiratory current constantly conveys to the sponge *fresh water for respiratory purposes*, and at the same time *food*. The latter, as in the bivalve molluscs, can only consist of the minutest living organisms and of finely-divided, decaying matters contained in the water; for a sponge, in the absence of prehensile organs, such as we have seen to exist in its nearest allies, the likewise sessile polyp, would be unable to capture prey of larger size.

(*d*) No specialized organs of respiration and digestion are developed in sponges, any more than in cœlenterates. There is no single body cavity, but as we have seen in Section C, *b*, numerous canals and chambers. In many respects the sponges differ in structure from all other animals.

In the sponges which we have discovered we notice, however, *several* exhalant apertures, or oscula, to which, accordingly, several branched canal systems must correspond. Such is evidently the case, but only in

Digitized by Google

older and large specimens. A young sponge (as shown in the illustration) invariably possesses only *one* osculum, and it is only after new sponges, all of which remain attached to it, have been produced from it by lateral budding that we meet with several of such apertures. Hence *an old sponge represents a colony which has been produced from a single individual by gemmation.*

(*e*) The actual body of a sponge is much softer than that of the fresh-water polyp (which see, Section C). It acquires, however, a certain firmness by the deposition in the protoplasm of thousands of hard, pointed *needles* or *spicules*. They consist of lime or of silica which has been taken up by the sponge from the water and again separated. The spicules are usually grouped together in bundles, forming a solid skeleton, which may be distinctly seen in dried specimens.

D. Reproduction.

In addition to multiplying by *buds* (see Section C, *d*) and *eggs*, the fresh-water sponges continue their species by another very peculiar mode of reproduction. In the autumn spherical bodies about the size of a mustard-seed, and surrounded by a thick coriaceous capsule, are found in the interior of the sponge. These bodies are known as *gemmules*. Whilst the sponges are (with few exceptions) killed by the winter cold, these gemmules survive, and give rise in the following spring to new sponges. They are also able to survive the complete drying-up of the water in which they were produced (a very important fact in hot districts); hence they play a part analogous to that of the hard-shelled eggs of fresh-water polyps. (See p. 469. Why do marine sponges not need gemmules for the purpose of their preservation?)

Other Sponges.

The sea, contrary to fresh water, possesses a superabundance of sponges of the most varied form and colour. Most of them are sessile, like fresh-water sponges, and united in colonies, their soft bodies being supported by silicious or calcareous spicules or by horny fibres. Among the few which are important to man, the **Bath Sponge** (*Euspongia officinalis*) holds the most prominent position. Its soft and elastic horny skeleton, which exactly reproduces the shape of the living animal, is generally familiar. The animal lives in the Mediterranean, especially in the Adriatic. The sponges are detached by men in boats, by means of long four-pronged forks, and pressed out on shore; the decaying soft tissues are next removed, and the sponge is finally thoroughly rinsed in fresh water. The less valuable sponges with large circular holes belong to another species, the so-called **Horse Sponge** (*Hippospongina equina*), from the north coast of Africa.

Digitized by Google

DIVISION OR TYPE VIII.: PROTOZOA.

Body composed of a single cell, the organs of the higher animals being therefore absent.

CLASS I.: INFUSORIA.

Protozoa of a definite shape, the surface of which is wholly or partially covered with cilia, with definite oral and anal apertures.

The Slipper Animalcule (*Paramœcium aurelia*).

(Length about $\frac{1}{100}$ inch.)

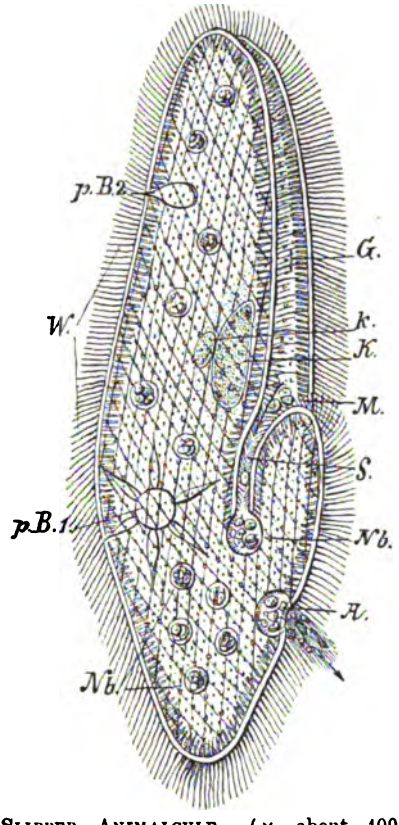
(With remarks on Protozoa and Infusoria in general.)

A. Name.

In 1675 the celebrated Dutch naturalist Van Leeuwenhoek (pronounce "Layvenhook") placed some pepper in a glass and covered it with water. A few days after, on examining a drop of the liquid under the microscope, he found, to his astonishment, a number of minute animals swimming rapidly through the water. He had, in fact, discovered the wonder-world of the minutest living organisms. Owing to the fact that these animals were obtained by pouring water on all sorts of vegetable, animal, and mineral substances—*i.e.*, by making infusions—they were called *Infusoria*, which name they retain to the present day.

To obtain a view of these creatures, we shall proceed in exactly the same manner as their discoverer. If we steep some hay in water, we shall find a few days after every drop of it alive with Infusoria. The whitish films on the surface especially teem with these creatures. (Examine for the same purpose ponds and pools.) The commonest species among these is certain to be one having the shape of the sole of a shoe or slipper, and hence called the "slipper animalcule." For this reason, and on account of its relatively large size, we shall here consider this species as an example of the whole class.

Digitized by Google



SLIPPER ANIMALCULE. (× about 400 times.)

K. and k., Nucleus and paranucleus; W., cilia—only those at the margin visible; G., depression in protoplasm, or vestibule, at bottom of which is placed M., the mouth, which is continued into S., the gullet. A few food particles are shown being swept through each. The gullet is shown just open to allow a few food particles, surrounded by water, and together constituting the food vacuole (Nb.), to enter into the interior of the cellular body. Eleven other similar vacuoles are shown; the undigested materials of a twelfth are being expelled at the anus (A.). p.B.1., Contractile vacuole, which is filled with fluid by six canals arranged in the form of a star; p.B.2., the second contractile vacuole, which is just opening on the exterior.

B. Structure.

(*a*) As a house is built up out of stones, so the body of all the animals hitherto considered is composed of a large number of very minute bodies called cells (see pp. 253 and 468). The body of the slipper animalcule (and of all Protozoa), on the other hand, consists only of *a single cell*. This cell consists of a minute speck of an albuminous substance which has been termed *protoplasm*, and in which two distinct structures are found, viz., a *nucleus* and a *paranucleus* (K. and k.).

(*b*) This unicellular condition also explains the *small size* of the *Protozoa*, and the *absence* in them of *organs* such as are found in the higher animals, seeing that even a *single organ—e.g.*, a muscle—already consists of many thousands of cells. (Protozoa are, in fact, "organisms without organs.")

(*c*) As the *surface* of the body of an infusorian is always somewhat denser than the rest of the protoplasm, these animals acquire a *definite shape* (contrast with Rhizopoda). This body surface is either entirely (as in slipper animalcule) or partially (as in bell animalcule) covered with vibrating cilia (W.), which serve as *locomotor* organs, and also for sweeping in

(*d*) *Food.* This consists of decaying substances, which are found everywhere in water in a finely-divided state (see fresh-water mussel), or of minute algæ and other microscopic organisms. The substances, however, cannot penetrate through the denser superficial protoplasm. By introducing a little

Digitized by Google

finely powdered carmine or indigo into the water, we shall be able to observe how such bodies are conveyed into the interior of the animalcule. We shall see that some of the pigment granules are swept by the cilia of the "vestibule" (G.) to the bottom of the latter, and thence through a small opening, the *mouth* (M.), into the *gullet* (S.). The particles are next seen to surround themselves with a drop of water and to be absorbed by the soft protoplasm. The food particles, surrounded by fluid in the so-called *food vacuoles* (Nb.), circulate through the cell and are digested, whilst the indigestible materials are expelled at another spot in the denser superficial protoplasmic layer, through the so-called anus (A.).

In the interior of the cell are found two other larger vesicles. These are usually connected with a number of radiating canals, giving them a starlike appearance, and are filled with fluid entering by the latter, and discharged periodically to the exterior. As these vesicles are also constantly dilating and contracting, they have been termed *contractile vacuoles* (p.B.). They probably discharge the same functions as the kidneys of higher animals.

C. Habitat.

On account of their delicate organization, Infusoria, like all other Protozoa, can only exist in *damp surroundings*. (Compare with vineyard snail and fresh-water polyp.) Hence, with the exception of a few, which live parasitically in the bodies of other animals, all are *inhabitants of the water*. When food becomes scarce, and if the ponds and streams freeze or dry up, the Protozoa inhabiting the latter surround themselves with a thick *capsule-like envelope*. (Compare with fresh-water polyp and sponge.) They are carried away with the dust, to be again moistened by water and reawakened to a new life. *This also explains their appearance in the infusions above referred to.* (Why do not marine Protozoa require such a protective envelope?) It further explains the wide

D. Distribution of the Fresh-Water Protozoa.

These animals may sometimes be carried over many hundreds of miles by storms; accordingly, they are *cosmopolitan* in their occurrence.

E. Reproduction.

The rapidity with which Infusoria multiply in infusions may be easily recognised. In a few weeks the descendants of a single individual will amount to millions. Reproduction takes place by *fission*. A constriction appears over the middle of the body, which becomes gradually deeper, until the animal finally divides into two. Previously, however,

Digitized by Google

both the nucleus and nucleolus have also undergone division, and a half of each becomes incorporated in the protoplasm of each portion of the divided animal. From time to time, also, fusion or conjugation takes place between two separate individuals, which subsequently form a single individual.

Other Infusoria.

There is perhaps scarcely a piece of water which is not inhabited by infusorians of the most varied form. Besides free-swimming species, there are also many others which are attached to other objects. To the latter belongs the **Bell Animalcule** (*Vorticella*). This infusorian is attached to water-plants, stones, etc., often in such quantities that these objects appear to be covered with a fine mould. This pretty little animal resembles a small bell (name), with a very long stalk, which is fixed to the supporting surface, and which can be extended and contracted like a spiral spring. The "mouth of the bell" is fringed by cilia which are in constant motion, and sweep food towards the mouth of the creature.

CLASS II.: THE FLAGELLATA.

The **Flagellata**, like the Infusoria, have a body of definite shape, but for purposes of locomotion and for sweeping in food they are possessed of several—sometimes only one—long cilia, or whip-like filaments, called flagella (name). One of the most common of these organisms often occurs in such quantities as to turn rain-water in gutters, ditches, and pools to a perfectly green colour. The body of this minute animal, in fact, contains the same green colouring matter (chlorophyll) as is found in the leaves of plants. Hence, like the latter, the animal is able to decompose carbonic acid gas and to use the carbon for the building up of its body (compare p. 465, note). At the anterior end of the body, which carries a very long flagellum, is seen a small round spot, very similar to an eye, on account of which this delicate creature has been named *eye-animalcule* (*Euglena viridis*, from *glēnē*, Greek for an eye). However, naturalists no longer believe that this so-called eye-spot is sensitive to light.

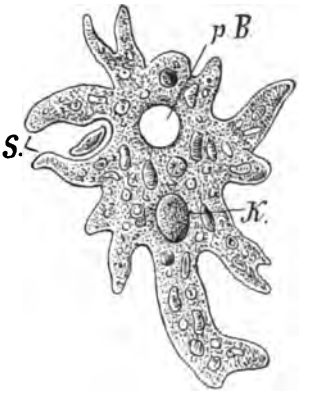
Another flagellate animalcule, *Noctiluca miliaris*, is brilliantly luminous when irritated, and sometimes occurs in great abundance in summer off the British coasts, making the phosphorescence of the sea unusually intense and beautiful.

Digitized by Google

CLASS III.: RHIZOPODA.

In the film of the hay infusion in which we found the slipper animalcule we shall, after some little search, discover another organism which resembles a minute speck of jelly. When at rest it soon begins to push out blunt root-like processes (Rhizopoda = root-footed), by means of which it slowly creeps about. When one of these "pseudopodia" comes in contact with a food particle, the latter is surrounded by the process and drawn into the body protoplasm. The indigestible remains are expelled from some other part of the body, which latter is constantly changing its shape. Hence, owing to the *surface layer of the protoplasm not being denser in these animals than the rest*, we meet with quite different arrangements to those of infusorians. Thus, the rhizopod requires neither a mouth nor an anus; it can protrude or retract now one part, now another, of its soft, protoplasmic body, after the manner of a foot, and accordingly possesses no constant shape. For this reason it has been descriptively named the **Proteus Animalcule** (*Amœba*).

Others of these delicate organisms surround their body with pretty shells composed either of foreign bodies (sand granules) or of chitinous or calcareous secretions. The pseudopodia in such cases are extended through one large opening or through numerous minute pores, or foramina; hence such Protozoa are known as **Foraminifera.**



AMŒBA, WITH PROTRUDED PSEUDOPODIA. (× about 100 times.)

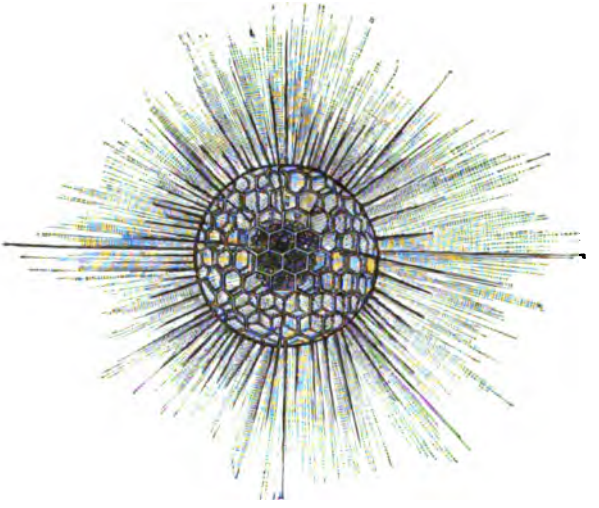
K., Nucleus; p.B., contractile vacuole. The protoplasm contains numerous ingested food particles. Two of the pseudopodia are in the act of encompassing a diatom.

Large strata of the earth's surface, *e.g.*, the chalk, are composed almost entirely of the calcareous shells of these microscopic creatures. They also cover immense tracts of the ocean bottom, out of which in some future age they may, perhaps, tower up as high mountain chains.

In another group of rhizopods, the pretty **Radiolarians**, only a portion of the body protoplasm is surrounded by a shell or capsule, the other portion lying outside of the latter. The skeletons of these minute Protozoa, all of which are marine, display a marvellous variety of shape, and, as may be seen from the illustration of *Heliosphera actinota*, a

Digitized by Google

Mediterranean species, are of such wondrous beauty that they ought certainly to be counted among the greatest marvels in Nature's workshop.



HELIOSPHERA ACTINOTA. (× about 100 times.)

The protoplasmic body is surrounded by a fenestrated silicious shell, which is furnished with numerous large and small spines. Within it is seen the capsule, the centre of which is occupied by the nucleus. Very delicate pseudopodia are seen radiating in all directions.

Digitized by Google

THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

Animal life is distributed universally over the earth. Even the most barren desert is traversed by some fleet-footed animal, and the ice-covered circumpolar seas form the habitat of a varied animal world. Nor has this world any limit, either above or below; for over the ice-clad peaks of the highest mountains the condor and the eagle still speed their soaring flight, and recent discoveries have shown the existence of a rich world of the strangest animal forms inhabiting the nethermost depths of the ocean. The closer we approach the equator, side by side with the increasing luxuriance of the plant world (flora), the animal world (fauna), too, grows richer in species and individuals.

This would make it appear that the distribution of animals was conditioned by *climate*. Up to a certain degree this is correct; for an animal like the Polar bear, which is insensible to the Arctic cold, can no more exist in the tropics than animals belonging to the cat family, which are very sensitive to cold, can live in the frigid zone. Climate, however, is not the *sole* determinant factor in the distribution of animals, for regions under the same degree of latitude (*e.g.*, South America and Africa), or even closely neighbouring each other (*e.g.*, Celebes and Java), may possess a widely different fauna; whilst, on the other hand, the fauna of regions of different degrees of warmth (*e.g.*, that of Germany and North Africa) may present a great similarity.

Of very great importance in the distribution of animals is the fact that *the distribution of land and water has not always been the same as it is now.* The connecting bridges between different land masses (*e.g.*, between Great Britain and the Continent) have disappeared, islands being formed; whilst in another direction tracts of land (*e.g.*, the Sahara) have been elevated out of the ocean. Nor has the *climate* of any particular region always remained the same. Thus, in the Tertiary period lions existed in Central Europe, whilst in the succeeding Glacial Age reindeer, Polar bears, and other Arctic animals, flourished on our continent.

Digitized by Google

A principal agent in the distribution of animals, moreover, is their *capacity for migration*. As an instance, we may mention the case of the brown or migratory rat, which in the course of 200 years has spread itself over the whole of Europe, having almost completely exterminated the black rat. Nor must we neglect to consider man's influence on the distribution of animals, of which the rabbits of Australia and the feral oxen and horses of South America afford us striking proofs.

In treating the fauna of a particular region, naturalists are in the habit of laying special stress on the Mammalia inhabiting this region. According to this method of classification, the earth is divided into the following six great provinces, or zoological regions:*

1. **The Palæarctic Province** includes Europe, Northern Asia as far as the Himalayas, and Northern Africa as far as the Sahara. Characteristic animals: Horse, camel, deer, oxen and sheep. Large mammals are absent, viz., elephant, rhinoceros, hippopotamus, etc.

2. **The Nearctic Province** comprises North America to the Mexican deserts. The fauna much more resembles that of the Palæarctic than that of the Neotropical province. Characteristic animals: Buffalo, prong-buck. Several species, *e.g.*, the humming-birds, encroach from the South.

3. **The Indian Province** includes Asia south of the Himalayas and the Sunda Islands, with the exception of Celebes. Important animals: Orang-utan, gibbon, fruit-eating bats, tiger, lion, Indian elephant, Indian rhinoceros, zebu, peacock, pheasants, gavial.

4. **The Ethiopian Province** comprises Africa south of the Sahara, Southern Arabia and Madagascar (which, especially on account of the abundance of Lemurs, forms a distinctly defined subprovince). Characteristic animals: Gorilla, chimpanzee, baboon, lion, panther, leopard, hyæna, African elephant, African rhinoceros, hippopotamus, zebra, giraffe, antelope, Cape buffalo.

5. **The Neotropical Province** includes South America and Central America to the northern border of Mexico. Important animals: The platyrrhine monkeys, vampire bat, jaguar, puma, llamas, sloths, ant-eaters and armadillos, opossums, humming-birds.

6. **The Australian Province** comprises the Australian Archipelago and Celebes. Characteristic animals: Marsupials, the duck-bill, echidna (other native mammals are absent), the emu, the birds of paradise of New Guinea, and the apteryx of New Zealand.

* Only animals mentioned in this work have been considered in this classification.

Digitized by Google

INDEX

A.

Abramis, 280
Abraxas, 338
Acalephæ, 469
Acanthopteri, 289
Acarina, 412
Acherontia, 329
Acipenser, 297
Acorn shells, 426
Acrididæ, 394
Actiniaria, 473
Aculeata, 358
Æschna, 399
Agriotes, 352
Ai, 132
Air-breathing gastropods, 428
Alauda, 181
Albatross, 225
Albino, 45
Alcedo, 170
Alces, 112
Alcidæ, 227
Alcyonaria, 475
Alcyonarian corals, 475
Alligator, 246
Alpaca, 119
Alpine hare, 88
Alpine marmot, 80
Amazon parrot, 173
Amblystoma, 265
American ostrich, 208
Ammonites, 445
Amœba, 483
Amphioxus, 304
Amphibia, 252
Amphipoda, 423
Anaconda, 241
Anas, 216
Anchovy, 288
Angora goat, 105
Anguilla, 288
Anguis, 234
Annelida, 446
Anodonta, 439
Anseriformes, 216
Anser, 221
Ant-eater, 132
  long-haired, 138
  spiny, 138
Antedon, 463
Antelope, 105
Anthozoa, 473
Ant-lion, 382
Ants, 369
Anura, 255
Ape, Barbary, 22
Apes, 17
  Old World, 22
Aphaniptera, 381
Aphis, 387
Aphis lion, 384
Aphrophora, 387
Apis, 358
Apple-blossom weevil, 354
Apteryx, 208
Apus, 425
Aquila, 158
Arachnoidea, 405
Araneina, 405
Arctiidæ, 330
Arctomys, 80
Ardea, 210
Arenicola, 451
Argyroneta, 410
Argynnis, 327
Arion, 433
Armadillidium, 423
Armadillo, 423
Armadillos, 134
Aromia, 357
Arthropoda, 307
Arthrostraca, 422
Articulated animals, 307
Artiodactyla, 92
Arvicola, 85
Ascaris, 453
Asellus, 423
Ass, 123
Astacus, 413
Asterias, 459
Astur, 157
Ateuchus, 344
Athene, 163
Auchenia, 118
Auerochs, 98
Auks, 227
Aulastomum, 452
Aurelia, 469
Aves, 139
Avicula, 439
Axolotl, 265

B.

Baboons, 22
Bacillus, 398
Bacon beetle, 351
Bacteria, 398
Bactrian camel, 118
Badger, 46
Balanus, 426
Balæna, 125
Balænoptera, 130
Balaninus, 355
Barbary ape, 22
Bark beetle, 355
Barnacles, 426
Barn owl, 160
Bath sponge, 478
Bats, 59
Bearded vulture, 158
Bears, 50
Beasts of prey, 23
Beaver, 81
Bed bug, 385
Beetle mite, 412
Beetles, 339
Belemnites, 445
Bell animalcule, 482
Berry bug, 386
Bird lice, 391
Bird mite, 412
Bird spider, 410
Birds, 139
Birds of Paradise, 194
Birds of prey, 153
Bison, 105
Bitterling, 280
Bittern, 211

Digitized by Google

Bivalves, 435
Black Arches moth, 334
Blackbird, 187
Blackcap, 186
Black-headed gull, 225
Black grouse, 204
Black redstart, 186
Black-veined White, 326
Blatta, 398
Blind worm, 234
Blistering beetles, 353
Blister tape-worm, 457
Blue-bottle fly, 378
Blue shark, 299
Blue tit, 191
Blues, 327
Boa constrictor, 241
Boat fly, 386
Bombinator, 260
Bombus, 368
Bombyx, 332
Bonasa, 204
Bony fishes, 277
Book scorpions, 411
Boring molluscs, 440
Bos, 98
Bostrychus, 355
Botaurus, 211
Bothriocephalus, 457
Brachycera, 375
Bradypus, 132
Bream, 280
Brimstone butterfly, 327
Broad-nosed apes, 22
Brown rat, 85
Brown-tail moth, 335
Bubalus, 104
Bubo, 162
Buffalo, 105
Bufo, 260
Bugs, 385
Bullfinch, 179
Buntings, 179
Burnet, 331
Burying beetle, 350
Bustard, 214
Butcher bird, 189
Buteo, 153
Buthus, 411
Butterflies, 318

C.

Cabbage butterfly, Large White, 318
Cabbage moth, 336
Cacatuidæ, 173
Cachalot, 131
Caddis flies, 384
Caiman, 246
Calandra, 355
Calosoma, 346
Camberwell Beauty, 327
Camel, 115
Camelopardalis, 114
Camelus, 115
Canary, 179
Cancer, 422
Canidæ, 35
Canis, 35, 38, 41
Cape buffalo, 105
Capelin, 296
Capercailzie, 204
Capra, 105
Caprimulgus, 174
Carabus, 345
Carassius, 280
Carcharias, 299
Carcinus, 422
Cardium, 440
Carnivora, 23
Carp, 277
Carpocapsa, 338
Carpocoris, 386
Carrion crow, 193
Cassowary, 208
Castor, 81
Casuarius, 208
Catarrhini, 21
Catocala, 336
Catodon, 131
Cats, 24
Centipedes, 404
Cephalopoda, 442
Cerambyx, 356
Cervus, 108
Cestodes, 454
Cetacea, 125
Cetonia, 344
Chætopoda, 446
Chaffinch, 176
Chameleon, 235
Chamois, 106
Charadriidæ, 214
Cheese fly, 378
Cheimatobia, 336
Chelidon, 184
Chelifer, 411
Chelone, 251
Chelonia, 246
Cherry fly, 379
Chersidæ, 250
Chilopoda, 404
Chimpanzee, 22
Chiroptera, 59
Chrysomela, 357
Chrysopa, 384
Chrysotis, 173
Cicada, 387
Cicindela, 346
Ciconia, 209
Cirripedia, 425
Clearwings, 330
Click beetles, 351
Clio, 435
Cloacal animals, 137
Clothes moth, 338
Clupea, 283, 288
Cnethocampa, 335
Cnidaria, 468
Cobitis, 281
Cobra di capello, 243
Coccinella, 357
Coccothraustes, 178
Coccus, 390
Coccygomorphæ, 168
Cochineal insect, 390
Cockatoos, 173
Cockle, 400
Cockroach, 398
Cod, 294
Codlin moth, 338
Cœlenterata, 465
Coleoptera, 339
Colias, 327
Collared turtle-dove, 199
Collocalia, 174
Colorado beetle, 357
Columba, 195
Condor, 158
Coot, common, 215
Copepoda, 424
Corallium, 475
Corals, 474
Corn beetle, 346
Corncrake, 215
Corn moth, 339
Corn weevil, 355
Coronella, 240
Corvus, 192
Cossus, 330
Coturnix, 203
Cotyle, 185
Cowry, 434
Crabs, 412, 422
Crangon, 420
Crane, 216
Crane flies, 381
Crayfish, 413
Crested grebe, 225
lark, 182
newt, 264
Crex, 215
Cricetus, 84
Crickets, 395
Crinoidea, 463
Crocodilus, 245
Crossbill, 179
Crotalus, 244
Crows, 192
Crustacea, 413
Cuculine birds, 168
Cuculus, 168
Culex, 379
Curculionidæ, 354
Currant moth, 338
Cursores, 205
Cursoria, 398
Cursorial birds, 205

Digitized by Google

Cuttle fishes, 442
Cyclostomi, 303
Cygnus, 221
Cynips, 373
Cynocephalus, 22
Cynopithecini, 22
Cypræa, 434
Cyprinus, 277
Cypselus, 173

D.

Dabchick, 226
Daddy long-legs, 381
Dama, 112
Daphnia, 425
Dasypus, 134
Dasyurus, 136
Death's Head moth, 329
Decapoda: Cephalopoda, 445
Crustacea, 413
Deer, 108
Deilephila, 328
Dendrocopus, 163
Denticetæ, 130
Dermanyssus, 412
Dermestes, 351
Desoria, 404
Devexa, 114
Dibranchiata, 442
Didelphys, 136
Diptera, 375
Divers, 225
Dog, 38
Dog lice, 391
Dog-like apes, 22
Dogs, 35
Dor beetles, 344
Draco, 235
Dragon fly, 399
Dreissena, 440
Dromæus, 208
Dromedary, 115
Drone fly, 378
Dryocopus, 168
Duck, domestic, 216
Duck-mole, 137
Ducks, 216
Dung beetles, 344
Dyticus, 347

E.

Eagle owl, 162
Earth-worm, 446
Earwig, 398
Echidna, 138
Echinodermata, 459
Echinus, 464
Ectopistes, 199
Edentata, 132
Edible crab, 422
frog, 255
turtle, 251
Eel, 288
Eider duck, 221
Elateridæ, 351
Electric eel, 302
ray, 302
Elephant, 89
Elephas, 89
Elk, 112
Emberiza, 179
Emu, 208
Emys, 247
Enamel-scaled fishes, 297
Entomostraca, 423
Epeira, 405
Ephemeridæ, 403
Equus, 119
Erinaceus, 74
Eristalis, 378
Ermine, 45
Erythacus, 186
Esox, 281
Euglena, 482
Eunectes, 241
Euspongia, 478
Exocœtus, 292

F.

Falco, 156
Falcons, 153
Fallow deer, 112
False caterpillars, 374
Feather stars, 463
Felidæ, 24
Felis, 24
Ferret, 45
Field cricket, 395
Fieldfare, 188
Field mouse, 85
scorpion, 411
Finches, 176
Finner whales, 130
Fire-bellied frog, 260
Fishes, 267
Flagellata, 482
Flamingo, 221
Flat fishes, 294
Flea beetle, 357
Fleas, 381
Flies, 375
Flounder, 294
Flying dragon, 235
fish, 292
fox, 67
Foraminifera, 483
Forficula, 398
Formica, 369
Fowl, domestic, 199
Fox, 41
Fox, flying, 67
Fresh-water mussel, 435
polyp, 465
shrimp, 423
sponge, 476
Fringilla, 176
Fritillaries, 327
Frog-hopper, 387
Frogs and toads, 255
Fulica, 215

G.

Gad fly, 379
Gadus, 294
Gall flies, 372
Gallinaceous birds, 199
Gallinago, 213
Gallinula, 215
Gallophasis, 203
Gallus, 199
Gamasus, 412
Gammarus, 423
Ganoidei, 297
Garden bee, 368
spider, 405
warbler, 186
Garial, 246
Garrulus, 194
Gastropacha, 333
Gastropoda, 428
Gastrosteus, 290
Gazelle, 106
Geometridæ, 336
Geotrupes, 344
German cockroach, 398
Giant sirex, 374
tortoise, 250
Giraffe, 114
Glacier flea, 404
Glomeris, 405
Glossina, 379
Glow-worm, 352
Gnat, 379
Goat, 105
Goatsucker, 174
Gold beetle, 345
Golden-apple beetles, 357
Golden eagle, 158
Goldfinch, 178
Gold fish, 280
fly, 378
pheasant, 203
Gonepteryx, 327
Goose, 221
Gorilla, 22
Goshawk, 157
Grallatores, 208
Grampus, 130
Grape moth, 338
Graptolitha, 338
Grasshopper, 391
Great black woodpecker, 168
Great grey shrike, 190
kangaroo, 134
titmouse, 190
water beetle, 349
Greenfinch, 178
Greenland whale, 125

Digitized by Google

Green lizard, 234
tiger beetle, 346
turtle, 251
woodpecker, 168
Gressoria, 395
Grey flesh fly, 378
lag goose, 221
parrot, 173
Ground beetles, 345
Groundling, 281
Grouse family, 204
Grus, 216
Gryllotalpa, 395
Gryllus, 395
Guillemots, 227
Guinea fowl, 202
Gulls, 223
Gymnotus, 303
Gypaëtus, 158
Gyr-falcon, Greenland, 157
Gyrinus, 349

H.

Haddock, 297
Haltica, 357
Hammer-headed shark, 301
Hamster, 84
Hare, 86
Harlequin, 338
Harvest man, 411
Harvest spiders, 411
Hawfinch, 178
Hawk-bill turtle, 251
Hawk moths, 328
Hay-worm, 338
Hazel grouse, 204
Head louse, 391
Hedgehog, 74
Heliosphera, 484
Helix, 428
Hermit crab, 420
Heron, 210
Herring, 283
Herring gull, 223
Heterodera, 454
Heteroptera, 385
Hippocampus, 297
Hippopotamus, 97
Hippospongina, 478
Hirudo, 451
Hirundo, 182
Hobby, 157
Holothuroidea, 464
Homarus, 419
Homoptera, 387
Honey-bee, 358
Honey kite, 156
Hooded crow, 193
Hook-wings, 358
Hoopoe, 170
Hornet, 369
Hornet clearwing, 330
Horse, 119
Horse bot-fly, 379
leech, 452
sponge, 478
Horse-shoe bat, 66
House-cricket, 395
fly, 375
marten, 45
martin, 184
mouse, 85
scorpion, 411
spider, 410
Howling monkeys, 22
Humble-bee, 368
Humming birds, 175
Hyænas, 34
Hyænidæ, 34
Hydra, 465
Hydrachnidæ, 412
Hydroidea, 471
Hydrophilus, 349
Hydrozoa, 469
Hyla, 260
Hymenoptera, 358
with boring-organs, 372
with stings, 358
Hypoderma, 379

I.

Ibex, 105
Ichneumon flies, 372
Ichneumonidæ, 372
Impennes, 225
Infusoria, 479
Insect-eaters, 67
Insectivora, 67
Insects, 310
Isopoda, 423
Itch mite, 412
Iulus, 405
Iynx, 168
Ixodidæ, 412

J.

Jackal, 38
Jackdaw, 193
Jaguar, 34
Jay, 194
Jelly-fish, 469
June beetle, 344
Jungle-fowl, 200

K.

Kallima, 326
Kalong, 67
Kangaroo, great, 134
Kestrel, 156
Killer whale, 130
Kingfisher, 170
Kiwi, 208

L.

Lacerta, 231
Lac insect, 390
Lackey, 335
Ladybirds, 357
Lamellibranchiata, 435
Lamellicorn beetles, 339
Lamellicornia, 339
Lammergeier, 158
Lamprey, 303
sea, 304
Lampyris, 352
Lancelet, 304
Landrail, 215
Land tortoises, 250
Lanius, 188
Lapwing, 214
Lariform birds, 223
Larks, 181
Larus, 223
Leaf butterfly, 326
Leaf insects, 397
Leeches, 451
Lemurs, 23
Leopard, 34
Lepas, 426
Lepidoptera, 318
Lepisma, 403
Leptocardii, 304
Leptocephali, 289
Lepus, 86
Leuciscus, 280
Lice, 390
Limax, 433
Limnæa, 434
Lion, 31
Litorina, 434
Little grebe, 226
owl, 163
Liver fluke, 458
Lizard, viviparous, 233
Lizards, 231
Llama, 118
Loach, 281
Lobed medusæ, 469
Lobster, 419
Locusta, 391
Long beaks, 385
Long-eared bat, 59
Longicorn beetles, 356
Longipennes, 223
Loopers, 336
Louse, clothes, 391
Love-birds, 173
Lower Crustacea, 423
Loxia, 179
Lucanus, 345
Lucioperca, 290
Lug-worm, 451
Lumbricus, 446
Luscinia, 185
Lutra, 48
Lynx, 31
Lytta, 353

M.

Machetes, 213
Macrolepidoptera, 318

Digitized by Google

Magpie, 194
Mallard, 216
Mammals, 11
Mantis shrimp, 422
Marsupial mole, 136
Marsupials, 134
Marten, 43
  pine, 43
May-flies, 403
Microlepidoptera, 338
Migratory locust, 395
Millipedes, 405
Mink, 45
Monotremata, 137
Moorhen, 215
Moss bee, 368
Motacilla, 187
Murex, 434
Muridæ, 84
Mus, 85
Musca, 375
Musk beetle, 357
Mustang, 120
Mustela, 43
Mycetes, 22
Myriapoda, 404
Myrmecophaga, 132
Myrmeleon, 382
Mysticetæ, 130
Mytilus, 440

N.

Naja, 243
Narrow-nosed apes, 21
Narwhal, 131
Natatorial birds, 216
Nautilus, 445
  pearly, 445
Necrophorus, 350
Nemathelminthes, 452
Nematocera, 379
Nematophora, 468
Nepa, 386
Net-wings, 382
Neuroptera, 382
Newt, great water, 264
  smooth, 263
Nightingale, 185
Nightjar, 174
Nine-killer, 190
Nisus, 157
Noctiluca, 482
Noctuidæ, 336
Non-ruminants, 93
Non-venomous snakes, 236
Northern nightingale, 186
Notonecta, 386
Notoryctes, 136
No-wings, 403
Numida, 202
Nut weevil, 355

O.

Oak-leaf gall-fly, 373
Oar-legged crustacea, 424
Ocneria, 334
Octopoda, 445
Octopus, 445
Odd-toed ungulates, 119
Œstrus, 379
Oil beetle, 353
Oniscus, 423
Ophidia, 236
Ophiuroidea, 463
Opossums, 136
Orang-utan, 17
Orca, 130
Oriole, golden, 194
Oriolus, 194
Ornithorhynchus, 137
Orthoptera, 391
  gressorial, 395
  cursorial, 398
  leaping, 391
Oryctes, 345
Oscines, 176
Ostracoda, 424
Ostrea, 439
Ostrich, 205
Otis, 214
Otter, 48
Ovis, 105
Owl, 160
Ox, 98
  warble fly, 379
Oxyuris, 453
Oyster, 439

P.

Pachytylus, 395
Paguridæ, 420
Pale clouded yellow butterfly, 327
Palinurus, 420
Paludina, 434
Palumbus, 198
Pandion, 157
Panolis, 336
Panther, 34
Papilio, 327
Paramœcium, 479
Parrots, 171
Partridge, 203
Parus, 190
Passenger pigeon, 199
Passer, 178
Pavo, 202
Pea moth, 338
Peacock, 202
  butterfly, 327
Pearl mussel, fresh-water, 439
Pediculus, 391
Peewit, 214
Pelecanus, 222
Pelias, 241
Pelican, 222
Penguins, 227
Perca, 289
Perch, 289
Perch-pike, 290
Perdix, 203
Peregrine falcon, 157
Periplaneta, 398
Perissodactyla, 119
Periwinkle, 434
Pernis, 156
Petromyzon, 303
Phalangium, 411
Phascolomys, 136
Phasianus, 202
Phasmidæ, 397
Pheasant, 202
Philopterus, 391
Phoca, 53
Phocæna, 130
Phœnicopterus, 221
Pholas, 440
Phryganeidæ, 384
Phyllium, 397
Phyllopoda, 425
Phylloxera, 390
Physoclisti, 289
Physostomi, 277
Phytophthires, 387
Pica, 194
Pici, 163
Pieris, 326
Pig, domestic, 97
Pigeons, 195
Pike, 281
Pill millipede, 405
Pine beauty, 336
Pine hawk moth, 330
Pine lappet, 333
Pisces, 266
Pitheci, 17
Plaice, 292
Planorbis, 434
Plant lice 387
Plathelminthes, 454
Platyrrhini, 22
Plecotus, 59
Pleuronectes, 292
Plum moth, 338
Plusia, 336
Podiceps, 225
Podura, 404
Polar bear, 52
Polecat, 45
Pond mussel, 439
  snail, 434
  tortoises, 247
Poplar beetle, 356
  hawk moth, 330
Porpoise, 130
Porthesia, 335
"Post-horns," 434

Digitized by Google

Prawn, 420
Praying mantis, 396
Pristis, 303
Privet hawk moth, 330
Proboscidea, 89
Proboscidians, 89
Processional moth, 335
Prosimii, 23
Prosobranchiata, 434
Proteus, 265
Protozoa, 479
Pseudo-neuroptera, 399
Pseudo-scorpionina, 411
Psittacula, 173
Pteropoda, 434
Pteropus, 67
Pulex, 381
Pulmonata, 428
Puma, 34
Pupa-killer, 346
Putorius, 45
Pyrrhocoris, 385
Pyrrhula, 179
Python, 241

Q.

Quail, 203

R.

Rabbit, 88
Radiolaria, 483
Rails, 215
Raja, 301
Rallidæ, 215
Rana, 259
Rangifer, 112
Raptores, 153
Rat, 85
Rattlesnake, 244
Raven, 193
Rays, 299, 301
Red Admiral, 327
  ant, 369
Redbreast, 186
Red coral, 475
  deer, 111
Redstart, 186
Red underwing, 336
Reindeer, 112
Reptilia, 228
Rhea, 208
Rhinoceros, 124
Rhinoceros beetle, 345
Rhinolophus, 66
Rhizopoda, 483
Rhizotrogus, 344
Rhodeus, 280
Rhodites, 374
Rhombus, 294
Rhynchota, 385
Ring-dove, 198
Ringed snake, 236
River lamprey, 303
River snail, 434
Roach, 280
Road slug, 433
Rock pigeon, 195
Rodentia, 75
Rodents, 75
Roe deer, 108
Rook, 192
Rorqual, 131
Rose beetle, 344
  gall-fly, 374
Round-mouthed fishes, 303
Round worms, 452
Rudd, 280
Ruff, 213
Ruticilla, 186
Ruminants, 98
  antlered, 108
  hollow-horned, 98
Rupicapra, 106

S.

Sable, 45
Sacred beetle, 344
Salamandra, 261
Salanganes, 174
Salmo, 282
Salmon, 282
Saltatoria, 391
Sand hoppers, 423
  lizard, 231
  martin, 185
  stars, 463
Saperda, 356
Sarcoptes, 412
Sarcorhamphus, 158
Sardine, 288
Sauria, 231
Saw-fish, 303
Saw-flies, 374
Scale insects, 390
Scaly ant-eaters, 133
Scarabæi, 344
Scarlet bug, 385
  mites, 412
Schizoneura, 388
Sciurus, 76
Scolopax, 212
Scolopendridæ, 405
Scorpio, 411
Scorpions, 411
Sea anemones, 473
  cucumbers, 464
  eagle, 157
  horse, 297
  lilies, 463
  moss, 472
  urchin, 464
Seal, 53
Selachii, 299
Sepia, 442
Serinus, 179
Serpula, 451
Sertularia, 472
Sessilia, 330
Seven-spotted ladybird, 356
Sexton, 350
Sharks, 299
Sheat-fish, 282
Sheep, 105
Sheep's nostril fly, 379
Ship-worm, 441
Shore crab, 422
Shrews, 73
Shrikes, 188
Shrimps, 420
Silk-worm moth, 332
Silpha, 351
Silurus, 282
Silver Y moth, 336
Silver pheasant, 208
Simia, 17
Skipjacks, 351
Skylark, 181
Slipper animalcule, 479
Sloth, 132
Slugs, 433
Small cockchafer, 344
Smerinthus, 330
Smooth snake, 240
Smooth-nosed bats, 67
Snails, 428
Snipe, 213
Snipes, etc., 212
Sole, 294
Solea, 294
Somateria, 221
Song birds, 176
Song thrush, 188
Sorex, 73
Sour-worm, 338
Spanish fly, 353
Sparrow, common, 178
  hawk, 157
Sparrows, 178
Spectre lemur, 23
Spectres, 397
Sperm whale, 131
Spheniscidæ, 227
Sphingidæ, 328
Sphinx, 330
Spider crab, 422
Spiders, 405
Spiders, true, 405
Spiny lobster, 420
Spiny murex, 434
Sponges, 476
Spongilla, 476
Spotted salamander, 261
Sprat, 288
Spurge hawk moth, 328
Squilla, 422
Squirrel, 76
Stag-beetle, 345
Star-fish, 459

Digitized by Google

Starling, 191
Steganopodes, 222
Stick insects, 397
Stickleback, 290
Stinging fly, 379
Stomatopoda, 422
Stomoxys, 379
Stone bee, 368
  corals, 474
  marten, 45
Stork, 209
Straight-wings, 391
Striped click beetle, 352
Strix, 160
Strombus, 434
Sturgeon, 297
  Russian, 298
Sturnus, 191
Sugar mite, 403
Sus, 93
Swallows, 182
Swallow-tail, 327
Swan, mute, 221
Swift, 173
Sylvia, 186
Syrphus, 378

T.

Tabanus, 379
Tænia, 454
Tailed amphibians, 261
Talpa, 67
Tape-worm, 454
Tapirs, 124
Tarentola, 234
Tarpan, 120
Tarsius, 23
Tegenaria, 410
Teleostei, 277
Tench, 280
Ten-legged crustacea, 413
Tenthredinidæ, 372
Terebrantia, 372
Teredo, 441
Termitidæ, 403
Testudo, 250
Tetrao, 204
Thoracostraca, 413
Thornback ray, 301
Thread-worm of turnip disease, 454
Thread-worms, 452
Thrushes, 187
Thylacinus, 136
Thynnus, 292
Tiger, 33
Tinca, 280
Tinea, 338
Tipula, 381
Toad, 260
Toothed whales, 130
Torpedo, 302
Tortoises, 246
Tortoiseshell butterfly, 327
Tree-frog, 260
Tree-sparrow, 178
Trematodes, 458
Trepang, 464
Trichechus, 58
Trichina, 452
Trichodectes, 391
Triton, 263
Trochilidæ, 175
Troglodytes, 187
Trombidium, 412
Tropidonotus, 236
Trout, 283
Trypeta, 379
Tsetse fly, 379
Tubicolous annelids, 451
Tunny, 292
Turbot, 294
Turdus, 187
Turkey, 202
Turtle dove, 199
Turtles, 250
Turtur, 199
Two-humped camel, 118
Two-wings, 375
Tylenchus, 454
Tyroglyphus, 412

U.

Unio, 435
Upupa, 170
Uriinæ, 227
Uroceridæ, 372
Urodela, 261
Ursidæ, 50
Ursus, 50
Urus, 98

V.

Vampire, 67
Vanellus, 214
Vanessa, 327
Venomous snakes, 241
Vermes, 446
Vertebrata, 1
Vesicantia, 353
Vespa, 368
Vicuna, 119
Vine aphis, 390
Vineyard snail, 428
Viper, 241
Vorticella, 482
Vultures, 158
Vulturidæ, 158

W.

Waders, 208
Wagtails, 187
Walrus, 58
Warble fly, 379
Warbler, garden, 186
Wasp, 368
Water boatman, 386
  beetles, 347
  bugs, 386
  flea, 425
  measurer, 386
  mites, 412
  rat, 86
  scorpion, 386
  slater, 423
  spider, 410
  spring-tail, 404
  vole, 86
Weasel, 45
Weevils, 354
Whalebone whales, 130
Whale-food, 129
Whales, 125
Wheat-eel, 454
Whirligig beetle, 349
White ants, 403
Whites, 326
Wild boar, 93
  cat, 31
  duck, 216
Winged gasteropods, 434
Wing shell, 434
Winter moth, 336
Wolf, 35
Wombat, 136
Wood-borers, 330
Woodcock, 212
Wood-lark, 182
Wood-lice, 423
Woodpeckers, 163
Wood-pigeon, 198
Wood-wasps, 372, 374
Woolly aphis, 388
Woolly bears, 331
Worms, 446
Wren, 187
Wryneck, 168

Y.

Yellow-hammer, 179

Z.

Zabrus, 346
Zebra, 123
Zebu, 104
Zygæna, 301
Zygænidæ, 330

UNIV. OF MICHIGAN,

MAR 13 1912

Digitized by Google

PRINTED BY
BILLING AND SONS, LIMITED
GUILDFORD

Digitized by Google

Digitized by Google

Digitized by Google